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In this Issue

Inventory Public Water Supply
Streeter, Raneri
A Water Supply in 1766
Corporation Commission Jurisdiction *Hooker*
Water in Unincorporated Areas *Sydnor*
Occupational Deferment
Chlorine and Chloramine Tests *Hallinan*
Water Conditioning Steam Production *Long*
Utility Extension Rules
McNaughton, Longwell
Storage Reservoir Detritus *Ackerman, Lynde*
Financing Ohio Sewage Works *LaDue*
Watering Lawns
Refrigeration and Air Conditioning *Reichman*
Bank Payment Water Bills
WPB CMP-5A Regulation
Leaking Faucet Waste

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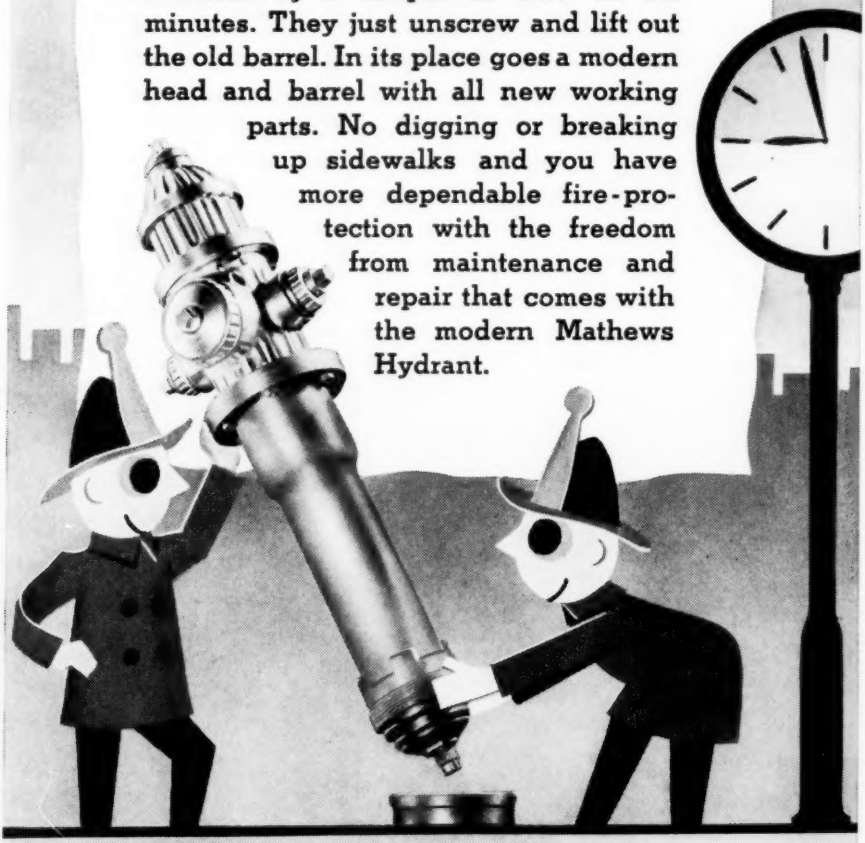

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Contents

National Inventory of Needs for Sanitation Facilities Public Water Supply. By H. W. Streeter and Ray Raneri 259

A North Carolina Water Supply in 1766 278

Jurisdiction of the State Corporation Commission. By H. Lester Hooker 284

Small Water Works for Unincorporated Areas. By Garland S. Sydnor ... 290

Occupational Deferment Water Works Employees 295

Tests for Active Residual Chlorine and Chloramine in Water. By Francis J. Hallinan 296

Conditioning Water for Steam Production. By F. H. Long 303

Fundamentals of Utility Extension Rules. By E. F. McNaughton 311

Discussion by J. S. Longwell 314

Effect of Storage Reservoir Detritus on Ground Water. By T. V. Ackerman and E. J. Lynde 315

The Ohio Plan for Financing Sewage Works Improvements. By Wendell R. LaDue 323

Watering Lawns 330

Municipal Regulation and Sanitary Control of Water for Refrigeration and Air Conditioning. By Irving Reichman 334

Bank Payment of Water Bills 357

Report of the Audit of Association Funds for the Year Ending December 31, 1943 359

Abstracts of Water Works Literature 364

How Much Does a Leaking Faucet Waste? 376

WPB CMP Regulations 5A 380

Coming Meetings iv

News of the Field 1

Changes in Membership 26

Changes in Address 36

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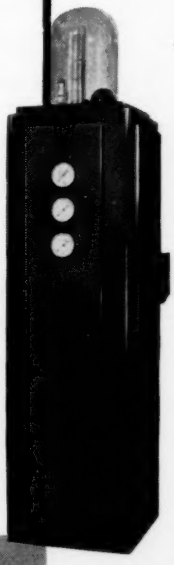

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Vol. 36 March 1944 No. 3

National Inventory of Needs for Sanitation Facilities

Public Water Supply

By H. W. Streeter and Ray Raneri

Introduction

OF the various public utilities which modern community life requires, none is more important or indeed more essential to the continued prosperity and health of the community than an adequate supply of good water. This truism has been so widely and, on occasion, so forcibly demonstrated that few if any well-informed persons would dispute it.

The dependence of public health on a good water supply goes far beyond the mere requirement that such a supply be free from the possibility of transmitting water-borne disease. If the public health in a community be viewed in its broader modern sense as being concerned not only with the negative question of preventing disease but also with the more positive one of promoting good health among all citizens, the wider implications of a good water supply are evident.

In this connection it is only necessary to point out a few instances familiar to everyone. Among these are the protection of life and property against fire and the proper sanitation of the community, such as street cleaning and the rapid and effective disposal of sewage and other water-carried wastes. These services are dependent on an ample quantity of water from a public supply, but its quality and palatability are also involved very directly in such matters as the consumption of physiologically adequate quan-

An article by H. W. Streeter, Sanitary Engr. Dir. in charge of Office of Stream Pollution Investigations, U.S. Public Health Service, Cincinnati, O., and Ray Raneri, Past Asst. Engr., Head of Information and Survey Unit, Sanitation Section U.S. Public Health Service, Washington, D.C. Republished from Public Health Rpts. of Jan. 7, 1944, by permission of the U.S. Public Health Service, Washington, D.C.

This article is reprinted because of its importance to the water works field at the present time. While certain statements in the article related to useful life of water works structures appear to be unduly conservative, they do not substantially detract from this fine study. The U.S. Public Health Service and its staff members deserve great credit for the work that has been done.

tities of water by individuals, the economical use of water for laundry and other household cleaning purposes, and the avoidance of unsafe local sources of water supply for drinking purposes whenever the public supply is objectionable in taste or appearance or unsuitable for culinary purposes. All of these phases of the use of water have an important bearing on public health, quite aside from the paramount requirement of its safety for human consumption.

In undertaking the present study of public water supply needs in the various States, the problem has been viewed from this broader angle of providing not only for the elimination of water-borne disease but also of insuring to every community a public water supply meeting the two basic requirements of ample quantity and satisfactory quality for all of the ordinary water uses of a community. The inventory has considered in detail every phase of such requirements with two exceptions, namely, (1) the freedom of water supplies from excessive hardness, which is to a large extent an economic problem, and (2) freedom from iron and manganese. In a section of this paper, the particular question of hardness and its economic cost will be discussed, however, in its relation to the general problem of public water supplies in certain areas of the country where hard waters are common.

Before taking up the inventory proper, it will be desirable to sketch very briefly the present status of public water supplies in the United States, to indicate broadly the general requirements for satisfactory supplies, and to point out some of the more important economic losses involved in failure to meet these requirements, together with the economic benefits resulting from correction of such deficiencies.

Present status of public water supplies in the United States

In the United States, public water supplies date historically from the year 1652, when the first system of this kind was instituted at Boston. At the end of the year 1800, some 150 years later, 17 water works systems existed in this country. Fifty more years passed before these systems numbered 100, but in 1900 they had increased to about 3,200 and in 1924 to 9,000 (1). In 1940 they approximated 14,500 and at the present time are estimated to serve about 84,500,000 people, or slightly less than two-thirds the total population of the entire country. The phenomenal development of public water supplies in the United States within the past 50 years, amounting to nearly a fivefold multiplication in their total number, probably is without parallel in water works history.

A recent census of water treatment facilities in the United States, conducted by the Public Health Service (2), together with supplementary data on untreated supplies, has shown that the greatest deficiency in public water supplies exists in the smaller communities having populations under 1,000, as indicated by the following comparison between the total numbers of incorporated places, divided into three groups according to their populations, and the numbers of these communities served by public water systems:

Population	*Total Number of Incorporated Places—1940 Census*	*Number of Incorporated Places with Public Water Supplies*
5,000 and over	2,042	2,033
1,000 to 4,999	4,627	4,304
Under 1,000	10,083	4,438

From this tabulation it appears that over 99 percent of the communities in the largest population group, 5,000 and over, are served by public water systems and about 93 per cent in the middle group, but only 44 per cent in the lowest group of less than 1,000 population. The census also has disclosed that approximately 10 million people, comprising about 11 per cent of the total population served by public water supplies, are supplied with water receiving no treatment.

According to the data collected from the Public Health Service's water purification census up to the end of the year 1941, approximately 75,100,000 people, or 89 per cent of the total population served by water supply systems, are furnished with treated water from some 5,535 treatment plants. The classification of treatment furnished, based on data for all of the 48 States combined, was as follows at the end of the year 1941:

Treatment	Percent of Total by—Number of Plants	Population Served
Rapid-sand filter purification	(30.8)	(44.2)
Purification only	28.8	37.4
With softening	2.9	6.2
With iron and manganese removal	0.1	0.3
Slow-sand filter purification	1.8	5.8
Iron and manganese removal	8.7	3.5
Softening only	5.0	1.9
Simple chlorination and miscellaneous chlorination	47.0	43.3
Iron and manganese removal, with softening	2.7	0.7
Miscellaneous (without chlorination)	2.8	0.7

Although simple chlorination, serving about 32,400,000 people through 2592 plants, is the process most frequently used, rapid-sand filter purification, with 1754 plants, serves a slightly greater population (about 33,000,000). Water softening either alone or in combination with other treatment serves about 6,700,000 people through 587 plants, of which 426 plants use softening alone or in combination with iron removal. Slow-sand filter purification serves about 4,300,000 people through 98 plants.

During the few years preceding the entry of the United States into the present war, the construction of new water systems and the improvement of old ones proceeded very actively under the stimulus of federal aid projects of the Public Works Administration and the Work Projects Administration. With our entry into the war, this work was suspended, except for water supplies urgently needed at military posts and training camps and, in some cases, in vital war industrial areas where sudden and large increases in population have overtaxed existing facilities. At the present time, established water works systems are being maintained with the barest minimum of repairs and replacements, owing to scarcity of metals and other critical materials needed in war production.

This situation, which of necessity will continue throughout the remainder of the war, will mean a progressive retrogression in the existing water supply facilities of the country which, together with the suspension of ordinary extensions to meet normal population growth, will create a cumulative deficiency to be made up after the war.[1] An added stimulus to postwar rehabilitation and improvement of public water supplies will be the increasingly widespread demand for new supplies by many communities, especially the smaller ones which now lack such fa-

[1] According to a recent estimate by Wolman, the expenditure of about 20 million dollars per year will be required immediately after the war to make up this deficiency.

cilities, and also a tendency toward more exacting standards of quality for all water supplies, which will tend to create a general demand for improvements and additions in water treatment.

In some sections of the country, notably in the more densely populated areas of the Eastern and Middle Western States, the general problem of maintaining good public water supplies is complicated by two major developments which have presented a situation of increasing difficulty in recent years. These are: (1) a progressive depletion of ground water supplies as the result of overdrafts in underground reserves, and (2) a marked increase in pollution of surface sources of water by sewage and industrial wastes. The first-named tendency, which attained somewhat alarming proportions during the drought years of the 1930's, has necessitated in some cases the augmentation of ground supplies by those obtained from surface sources. This tendency will increase, if further depletion of underground water strata occurs. During the decade 1930–40, excessive pollution of surface sources of water supply resulted in the development of new sources at Toledo, Grand Rapids, Albany, Youngstown, Springfield (Ill.), Sandusky (Ohio), and Little Rock (3). These improvements cost altogether more than $20,000,000. In numerous other instances, raw water pollution has necessitated extension and elaboration of existing water-purification facilities, often at great expense. In general, water problems of this type are intimately related to those of waterways pollution and the ultimate solution of these two general problems will be likewise closely interdependent.

General requirements of a good water supply

In general, a satisfactory public water supply should be adequate in quantity and pressure to meet all domestic, industrial, and fire-protection needs of a community. It should be hygienically safe at all times for drinking and culinary purposes, should not contain excessive turbidity, color, hardness, or iron, and should be free from undesirable tastes and odors. It also should contain no toxic metals or other like substances such as lead or arsenic and should be free of certain materials such as phenols or cresols, which may cause objectionable tastes in treated water supplies. It should be relatively noncorrosive and should be sufficiently in equilibrium chemically so that no cumulative deposits of mineral salts will occur in piping and hot-water systems.

The amounts of water consumed in cities of the United States average about 120 gallons per capita daily,[2] with ranges of 80 to over 300 gallons in individual cities. Surveys have indicated that average rates of domestic consumption of water range from 30 to 50 gallons or more per capita, with 30 gallons as the estimated minimum. For ordinary residential districts, pressures of 25 to 40 pounds per square inch are required, though present practice favors carrying 60 to 75 pounds in order to provide adequate pressure for fire protection and to allow a large margin of fluctuation in local pressures in meeting sudden drafts. For fire protection, available flows ranging up to 12,000 gallons per minute are required, with an additional allowance of

[2] The recent Public Health Service census has indicated an average of 119 gallons in 29 States for which the best data are available.

2,000 to 8,000 gallons per minute for a second fire. In the Chicago stockyards fire of 1935, the rate of draft exceeded 50,000 gallons per minute. In general, the ordinary maximum daily consumption may exceed the yearly average by about 50 per cent and the maximum hourly consumption may exceed the daily rate by 50 per cent. In designing water systems, pumping, treatment, and distribution capacities are figured as high as 2.0 or 2.5 times the average rate of consumption, in order to allow for ordinary maximum rates of draft in addition to overdraft for fire protection.

Desirable quality requirements for public water supplies have been set forth in the Drinking Water Standards of the Public Health Service, of which the latest revision was issued September 25, 1942 (4). Although these Standards are intended to be applicable only for drinking and culinary waters supplied by common carriers in interstate commerce, they have been followed in a majority of the States as a criterion of quality for public water supplies in general. The Standards limit the number of coliform bacteria in a water to an average not exceeding 1 per 100 milliliters, these bacteria being indicative of undesirable pollution when present in higher concentrations. Additional requirements fix upper limits for turbidity and color of a water, and its content of lead, arsenic, and other undesirable metallic pollutants. No objectionable taste or odor is permissible. Although no limit is set for the total hardness, certain limiting requirements are suggested with respect to the total alkalinity at various hydrogen ion concentrations (pH). Appended to the Standards is a "Manual of Recommended Water Sanitation Practice," in which various sanitary defects in water supplies are described, together with suggested measures whereby such defects may be prevented or eliminated.

Economic losses from deficiencies in water quality

The costs of sanitary and other defects in the quality of water supplies have been studied by several observers, dating from the original work of the late George C. Whipple (5) about 35 years ago. Several estimates have been made of the economic losses due to deaths from preventable water-borne diseases such as typhoid fever and dysentery. On the basis of damage awards resulting from an outbreak of water-borne typhoid fever at Olean, N.Y., in the year 1928 Shaw and Chase (6) have estimated that each death from typhoid fever costs the community about $20,000; hence each death prevented may be considered as saving an equivalent sum. On the assumption that one-half of the reduction in deaths from typhoid fever recorded between 1900 and 1935 was attributable to increased safety of water supplies, the authors conclude that this saving due to pure water has amounted to the total sum of $400,000,000 annually in the United States.

On the same basis it may be estimated that the economic loss from deaths due to typhoid fever approximated $68,400,000 in 1935, when the death rate for the entire registration area was 2.8 per 100,000, and $21,200,000 in 1940, when the death rate reached the phenomenally low point of 0.8 per 100,000. If one-half the typhoid fever in 1940 was water-borne, the economic loss in this year due to deaths from this disease was roughly $10,000,000.

The same authors have considered the economic losses due to excessive amounts of turbidity, color, iron and manganese, and to undesirable tastes and odors in public water supplies. They have based their estimates in part on the recorded per capita expenditures for bottled spring waters not having these defects. Their conclusions on these points are that the annual losses due to these types of water quality impairment are very roughly as follows:

	Per Million Gallons Daily of Water Consumption	*Per Thousand of Population Annually*[3]
For turbidity exceeding 10 ppm	$400 per ppm	$48 per ppm
For color exceeding 5 ppm	200 per ppm	24 per ppm
For iron and manganese	1,000 per ppm	120 per ppm
For tastes and odors	$2,000 to $20,000 per year	$240 to $2,400

In a city of 100,000 population, a water containing 3 ppm. of iron would impose, on this basis, an economic loss amounting to $36,000 annually. At the minimum figure given for tastes and odors, the total cost of this impairment in the same city would be estimated at $200,000 annually. Both of these deficiencies in the quality of public water supplies have a definite public health significance because water consumers served with an iron-bearing or taste-producing water supply will tend to avoid such a supply in favor of other local sources which may be and frequently are hygienically unsafe.

The annual losses due to corrosive water vary widely with local conditions, as would be expected, but are always a definite item of cost in terms of shortened life of services and inside piping in homes, office buildings, and factories. In one case cited by Shaw and Chase, the loss due to corrosion was estimated at $36,500 annually per million gallons daily of water consumption. As pipe corrosion is a relative action, nearly always prevalent to some degree wherever water comes in contact with a corrodible metal, no generalized estimate can be made as to the total damage done by this agent, though it probably is very large and exacts a heavy annual toll in all water works systems.

Excessive hardness in a water supply, in addition to causing extra soap consumption, exacts a toll of shortened life for washable fabrics and cooking utensils, increased expense of maintaining plumbing, water tanks, and heaters, fuel losses in heating water in homes and factories because of scale formation, and the added costs of household water softeners and industrial boiler compounds.

Recent data have indicated that the combined annual cost of hard water averages from 1.0 to 1.5 cents per capita for each part per million of hardness in excess of 75 to 100 ppm. Shaw and Chase estimated that the annual losses at Dayton, Ohio, using a water of 350 ppm. hardness, were $3.50 per capita, as compared with the cost of using a softened water at 100 ppm. Estimates for 232 Kansas municipalities using water averaging 334 ppm. hardness have indicated an annual loss of 25 pounds of soap per capita. At 16 cents per pound, this represents a loss of $4 per capita per year.

An approximate estimate of the total economic loss due to use of hard water

[3] Assuming an average water consumption of 120 gallons per capita daily.

in over 600 cities surveyed by Collins in 1932, as analyzed by Olson in a recent paper (7), has indicated an annual cost of about $24,000,000, or roughly 90 cents per capita, for some 27,000,000 people using waters exceeding 90 ppm. hardness.

In addition to the cost of other deficiencies in the quality of our water supplies, it may be estimated very roughly that excessive hardness and water-borne disease probably exact an economic loss amounting to at least $35,000,000 annually, to which roughly $5,000,000 might be added for losses due to nonfatal illness from water-borne disease, including both typhoid fever and diarrhea-enteritis. The losses represented by other defects in the quality of water supplies, though of such a nature as to be highly variable and thus indeterminable, probably would amount to at least $10,000,000 annually and doubtless would exceed this sum by a considerable margin if they could be fully and accurately appraised. This would not include the economic losses due to pipe corrosion which, if known, would undoubtedly be represented by a far greater annual expense over the entire country than the figures above given would indicate.

Although it would be hazardous to fix a definite figure for the total economic loss now resulting from sanitary and other defects in the quality of public water supplies in the United States, it would seem fairly safe to say, from the evidence available, that such a figure would be not less than $50,000,000 annually and might be somewhat higher if more definite information were available concerning the total cost of such items as unpalatability, excessive turbidity and color, iron and manganese, and corrosiveness in water supplies. Added to this would be a certain, though intangible, economic loss to the country resulting from the absence of public water supplies in the 5,968 incorporated communities having populations less than 5,000. It is in these communities that Wolman and Gorman (8) have noted the greatest occurrence of typhoid fever, the number of outbreaks in such communities having been 72 per cent of the total during the period 1930–36. The needs of this large number of small communities for public water supply systems constitute probably the most important problem remaining to be solved in this particular category of community sanitation.

The Present Inventory

The present inventory was undertaken in March 1943 in connection with a general survey of sanitation needs instituted by the States Relations Division of the Public Health Service through its Sanitation Section.

Basic data for the inventory have been obtained from seven main sources, as follows:

1. United States census data for 1940, listing incorporated communities and their populations.

2. A national census of water treatment plants in the United States, up to the end of the year 1940, as compiled by the United States Public Health Service, with cooperation by State departments of health. Published in summary form in Public Health Reports, vol. 57, No. 45, Nov. 6, 1942, pp. 1679–1694, together with unpublished supplements for 1941 and 1942.

3. Reports of the National Resources Planning Board, dealing with water supply projects.

4. Reports of Lanham Act projects, as submitted for review by the Public Health Service.

5. Reports of reconnaissance surveys by the Public Health Service.

6. Public Works Administration water works non-Federal projects. Publication No. 101, Public Works Administration.

7. Engineering estimates for postwar construction from state and local agencies.

The inventory, which is based on a listing of individual communities in each state, includes all known improvements and extensions of existing water works, except water softening and iron removal installations, required to furnish adequate service as an extension of existing treatment facilities. Included also in the listing are new public water supply systems needed for all incorporated communities with populations exceeding 200, excepting the construction of new water softening and iron removal plants. The works included in the extensions would provide the convenience of a public water supply system to as much of the entire population as is deemed economically feasible and would reduce the hazards to public health associated with inadequate public systems or the use of unprotected local sources of water.

The water works projects listed would include, in addition to improvements and extensions of supply and purification facilities, the extension of water distribution systems and feeder mains and provision for complete new water systems, including facilities for supply, purification, and distribution. In many communities, both large and small, existing water systems are in need of extensions and improvements. These needs are caused by normal population growth, obsolescence and depreciation of existing facilities, increase in pollution of sources of water supply, and other similar elements. The need for improvements of this type is of greater than normal magnitude because of necessary curtailment of ordinary water works construction during the present war period.

The tendency of large communities to expand peripheral suburban areas creates a general need for water distribution extensions and increase in feeder main capacity in order to provide adequate service in outlying districts. Many smaller communities containing closely developed areas are in need of public water supply systems because of the hazards associated with unsupervised private water development. In some cases water supplies for neighboring groups of smaller communities can be developed on a water district plan, thus economizing on the provision of these facilities.

In Table 1 are listed the numbers of incorporated communities in each state, together with the numbers of these communities served by public water supplies according to three population groups. In the last column of the table is given the total number of incorporated communities served by public water supplies in each state. This table shows a total number of 16,752 incorporated communities in the 48 states, of which 10,775 are provided with public water supplies. Some 2,033 communities of 5,000 population and over are listed as having public water systems. Reference to a previous tabulation (page 260) will show a comparison of the total number of communities in each population group and the number provided with public water systems.

Method of compiling the inventory

The preliminary listing of incorporated communities over 200 in popu-

TABLE 1

Incorporated Communities Served by Public Water Supplies

State	Number of Incorporated Communities	Served by Public Water Supplies			
		Population Under 1,000	Population 1,000–4,999	Population 5,000 and Over	Total
Alabama	279	56	86	30	172
Arizona	34	3	13	10	26
Arkansas	414	64	87	22	173
California	286	35	138	110	283
Colorado	250	122	52	17	191
Connecticut	43	1	10	24	35
Delaware	52	11	16	2	29
Florida	273	73	88	35	196
Georgia	590	116	129	38	283
Idaho	151	35	39	11	85
Illinois	1,140	240	291	122	653
Indiana	529	135	29	68	232
Iowa	931	357	171	44	572
Kansas	589	221	107	32	360
Kentucky	323	69	105	29	203
Louisiana	210	40	76	28	144
Maine	26	....	6	20	26
Maryland	145	48	34	12	94
Massachusetts	122	....	9	113	122
Michigan	475	108	162	78	348
Minnesota	745	220	149	44	413
Mississippi	295	84	83	23	190
Missouri	793	75	139	47	261
Montana	115	52	35	12	99
Nebraska	531	305	88	17	410
Nevada	12	2	6	3	11
New Hampshire	18	....	2	16	18
New Jersey	344	65	127	122	314
New Mexico	63	16	21	14	51
New York	611	207	228	120	555
North Carolina	488	83	119	45	247
North Dakota	333	49	37	10	96
Ohio	873	170	243	115	528
Oklahoma	520	157	119	43	319
Oregon	207	112	50	16	178
Pennsylvania	989	127	308	205	640
Rhode Island	19	....	1	18	19
South Carolina	248	29	70	24	123
South Dakota	303	132	46	10	188
Tennessee	221	68	67	27	162
Texas	645	202	276	102	580
Utah	192	108	55	8	171
Vermont	75	14	22	10	46
Virginia	218	76	64	29	169
Washington	222	116	61	22	199
West Virginia	209	58	84	26	168
Wisconsin	512	142	132	54	328
Wyoming	89	35	24	6	65
Total	16,752	4,438	4,304	2,033	10,775

lation was obtained from the 1940 United States Census, together with their 1940 populations. These communities are listed by states. From the detailed information of the Public Health Service water purification census an estimate was made of the needed extensions of systems providing water treatment, in accordance with the difference shown between the total census population of each community and the population served by the present system. In this manner ratios were obtained of the total census population to population served which could be applied to estimating the necessary extension of distribution systems both on treated supplies and on untreated supplies, the latter listings being obtained from other sources. In estimating the needs, if the existing treatment capacity was shown to be more than 1.5 times the average water consumption, the capacity of the treatment system was considered as adequate; if otherwise, an increase in capacity to 2.5 times the present average consumption rate was considered necessary. This procedure was in accordance with usual practice in estimating needed extensions of water-treatment systems for future periods.

The data concerning needs for extensions of untreated water supplies not included in the Public Health Service treatment census were obtained from reports of the National Resources Planning Board, together with the other sources of information above noted. From the National Resources reports only projects not yet constructed were listed. From reports of the Lanham Act projects and the United States Public Health Service reconnaissance surveys were taken listed projects which had not been included in other sources of information. Estimates of requirements for new systems were obtained by comparison of lists of existing water supplies with lists of incorporated communities in each State as shown by the 1940 Census. In this connection, reference also was made to proposed projects listed in various issues of the engineering periodicals.

In order to establish a background for estimating the cost of future projects, a study was made of the per capita costs of water works projects as reported by the Public Works Administration in publication No. 101. This publication shows the location, description, and final cost of water works constructed by the Public Works Administration during the period July 1933 to March 1939. The following types of projects were considered separately from the report:

(1) New water works systems
(2) New purification works
(3) New sources and purification works combined
(4) New ground-water supplies

In these groups all projects containing extensions, renewals, and additions to present systems were excluded in order to show the true picture of the cost of completed new construction. New water works system costs include those of developing new sources (in most cases wells), construction of pumping stations, including buildings, and the construction of distribution systems. New purification works include sedimentation tanks, coagulation basins, rapid- or slow-sand filtration, pumping equipment, structure of housing and pumping equipment, and the necessary main extensions to connect the purification plant with the distribution system.

The third group, new sources and purification works, includes, in addi-

tion to treatment plants, new sources of supply which may have been from either a surface or a ground-water source.

The fourth group consists of projects in which new ground-water sources were developed, including pumps, structures to house the pumps, and main extensions to connect the source of supply with the distribution system.

In general, it is noted that the per capita costs of construction for new water supply facilities of all types tend to bear an inverse relation to the size of the population group served, that is, to diminish with increasing population.

Altogether 865 Public Works Administration projects were listed in the four categories—44 in treatment, 19 in source and treatment, 781 in completely new systems, and 21 in ground water supplies.

TABLE 2

Relation Between Average Size of Population Group and Corresponding Cost of Newly Constructed Water Supply Facilities

[Based on Public Works Administration contracts, 1933–39]

	Population Range	Number of Projects	Average Population	Average Cost Per Capita
Water works systems (complete, including source)	100– 500	246	370	$84.00
	500– 1,000	340	700	65.00
	1,000–10,000	195	1,800	45.00
Treatment works	100– 500	2	384	23.20
	500– 2,000	11	1,130	19.80
	2,000–10,000	23	4,320	15.00
	Over 10,000	8	39,800	9.20
Sources and treatment works combined	500– 2,000	4	1,350	28.40
	2,000–10,000	9	5,320	18.40
	Over 10,000	6	120,000	15.50
Ground water supplies	100– 500	4	430	16.20
	500– 2,000	12	1,230	7.30
	2,000–10,000	5	3,050	5.28

In order to analyze the data thus grouped, the projects were listed individually, the construction costs per capita computed, and these costs then averaged for the various population ranges. The average per capita costs thus obtained were then plotted against average populations for the several groups.

The base data for these plots are given in Table 2, divided into four sections according to the subdivision above indicated.

Construction costs have continued to rise from 1915 up to the present time, except for minor declines during short intervals. Following the last war, construction costs varied considerably but during the period 1920–30 averaged about 12 per cent higher than those prevailing during the war. Construction costs at the present time are about 32 per cent higher than in the period 1934–40. Following the present war,

insofar as experience of the last war is a guide, it is reasonable to expect further increase in costs above the present level.

Assuming this increase to be of about the same magnitude as it was after the last war, the inference would be that construction costs after the present war would be about 48 per cent higher than in the period 1934–40. Costs prevailing at this high level may have the effect of impeding many worth while public works, though indications are that some sort of price control will be maintained after the war to hold approximately to present costs. Any increase in construction costs above the present level will have the effect of increases in the estimates here shown. For this reason the total estimated costs for new water works construction based on per capita costs indicated in Table 2 for the period 1933–39 were increased 32 per cent to conform to present-day prices.

For the derivation of estimated costs of extensions and improvements to existing water works, a general figure of $35 per capita was used, $20 of which was allotted to source and treatment and $15 to distribution system improvements. Where detailed costs for such extensions and improvements have been directly available in sources above indicated, these costs have been used. For purposes of estimating total costs of extensions and improvements, the per capita costs were applied only to the populations benefited by such improvements and not to the total incorporated populations.

Included in the over-all estimate are costs for several improvements to existing water works, concerning which primary engineering studies of some type have been made, usually in the larger cities. With respect to these projects, actual engineering estimates amounting to $151,690,000 were prepared on the basis of present-day costs and no increase was allowed.

Results of the inventory

According to the estimates which have been prepared on the basis of the unit costs above given, the total estimated cost of additional water supply facilities needed, as indicated by the present inventory, is approximately $683,300,000 and is distributed as follows:

	Number	*Estimated Cost*
New systems	4,766	$180,960,000
Extensions or improvements	6,455	502,340,000

The numbers of incorporated communities, including their total populations, considered for new water works are listed by states in Table 3. In this table it will be noted that the total population of the lowest community size group (population 500 and under) is about twice the total population in the next larger group (population 501 to 1,000) and somewhat over four times the total population of the largest community group. The disparity between the total number of communities in the "500 and under" group and the total for the other two groups is much greater than the difference between their corresponding populations.

The total estimated costs of the additional water facilities needed is broken down by States in Table 4. In this table the costs of development and purification have been separated from the costs of distribution and the two estimates combined under the heading of "total costs."

It would be impracticable to show in this paper a complete breakdown of these estimates in terms of cost of wa-

TABLE 3

Incorporated Communities Considered for New Water Works

State	Population 500 and under		Population 501–1,000		Population over 1,001	
	Number of Communities	Total Population (1940)	Number of Communities	Total Population (1940)	Number of Communities	Total Population (1940)
Alabama	75	21,142	24	15,960	6	7,449
Arizona	....	....	5	4,375	3	4,142
Arkansas	193	50,114	29	19,460	3	3,422
California	....	....	1	677	....	....
Colorado	42	8,324	4	3,015	5	8,032
Connecticut	....	....	2	1,312	....	....
Delaware	14	3,957	2	1,164	....	....
Florida	45	12,638	17	11,311	6	9,754
Georgia	150	44,874	29	18,165	4	5,696
Idaho	47	14,904	11	5,833	....	....
Illinois	347	102,981	117	78,769	12	12,504
Indiana	147	42,529	33	21,032	5	5,680
Iowa	306	71,898	30	19,958	2	3,178
Kansas	203	49,754	18	11,041	2	2,464
Kentucky	69	21,013	20	13,077	4	5,231
Louisiana	44	14,715	14	9,474	5	8,061
Maryland	23	7,614	9	7,352	9	16,695
Michigan	94	32,508	27	17,438	3	4,934
Minnesota	211	57,956	29	17,462	2	2,782
Mississippi	90	23,804	14	8,422	2	6,618
Missouri	413	107,487	65	42,370	18	16,849
Montana	14	4,208	1	839	1	1,012
Nebraska	109	20,827	4	2,517	2	2,457
Nevada	....	....	1	964	....	....
New Jersey	9	2,791	6	3,329	1	2,128
New Mexico	7	2,163	4	2,969	....	....
New York	41	11,450	13	8,253	3	3,569
North Carolina	143	44,724	41	28,044	5	5,548
North Dakota	156	45,884	26	16,981	2	2,457
Ohio	205	67,027	72	44,161	4	6,295
Oklahoma	138	39,300	22	14,360	....	....
Oregon	9	2,079	2	1,231	....	....
Pennsylvania	9	2,734	9	6,265	3	5,217
South Carolina	61	18,982	18	10,120	7	12,122
South Dakota	67	17,867	8	4,769	....	....
Tennessee	27	7,687	1	560	3	4,683
Texas	41	10,809	11	7,364	12	17,988
Utah	16	4,269	5	3,481	2	9,292
Vermont	17	4,472	8	5,498	2	3,365
Virginia	41	12,662	5	2,952	2	2,257
Washington	12	3,651	3	2,108	2	4,023
West Virginia	32	9,010	8	5,430	1	1,133
Wisconsin	145	41,759	28	18,216	6	9,345
Wyoming	8	2,392	1	885	....	....
Total	3,820	1,027,959	797	518,963	149	216,382

NOTE.—Data for Maine, Massachusetts, New Hampshire, Rhode Island, and District of Columbia not included, as no incorporated communities have been considered for new water works in these States.

ter supply needs for individual communities, although this information has been collected and tabulated as a basis of the figures given in Table 4.

As the detailed projects for meeting these improvements will be to a very large extent the responsibility of the local communities, it hardly seems necessary or justified to undertake any such detailed presentation here. The real purpose of presenting the estimates in their present form is to indicate what the total costs of meeting these needs in the various states may be expected to approximate in relation to the cost of fulfilling other sanitation needs as they may be developed from the present inventory. These broad estimates also will serve as a basis for comparing at the level of present costs the estimated requirements of each State in relation to those for other States.

In compiling the data shown in Tables 3 and 4, no estimates have been included for the costs of added water softening facilities in the various states, or for the populations thereby affected. Based on Olson's figures for the population now consuming water of various degrees of hardness, it may be estimated very roughly that about 27 million people in the United States consume water which would require softening to bring it to a hardness level of 80 to 100 parts per million. According to the latest supplementary data from the Public Health Service water treatment census, approximately 6.7 million people were provided with water softening facilities in 1941. It therefore may be estimated that roughly 20 million people would still need such facilities if they could be provided. A similar estimate of needed facilities for removing iron and manganese from water supplies would be desirable but must be omitted here because of the lack of reliable data.

At present cost levels, it may be estimated that a first-class water softening plant with filters would cost about $50,000 per million gallons daily capacity. With a mean rate of water consumption of 120 gallons per capita daily, this would represent a construction cost of $6 per capita for softening plant. Applied to a population of 20 million, the total estimated cost would be $120,000,000 for softening of all water supplies not now thus treated and averaging more than 80 to 100 p. p. m. hardness. If this item be added to the total estimated cost of all other development and treatment facilities, as shown in table 4, the total cost under this item would be increased from $424,750,000 to $544,750,000 and the grand total for all water supply additions and improvements from $683,300,000 to $803,300,000.

In connection with these figures it is of particular interest to refer to an estimate of post-war needs for additions and improvements to existing water works systems in the United States compiled by the editor of the journal, Water Works Engineering, and published in that journal in February 1943 (9). This estimate did not include the cost of constructing complete new water systems for small communities, estimated in the present inventory at a total cost of $180,000,000. The total estimated cost of the additions and improvements to existing water supplies covered by Water Works Engineering was $650,000,000, based on data supplied from 92 cities of 100,000 population or more. This figure is slightly lower than the total of $683,300,000 derived from the present inventory, excluding water softening improvements. If the $180,000,000

TABLE 4

Cost Summary—Water Supply

[In thousands of dollars]

State	Development and Purification	Distribution	Total	State	Development and Purification	Distribution	Total
Alabama	2,420	4,490	6,910	Nebraska	3,640	5,130	8,770
Arizona	3,200	970	4,170	Nevada	80	70	150
Arkansas	3,130	6,400	9,530	New Hampshire	160	280	440
California	41,040	5,710	46,750	New Jersey	3,020	3,630	6,650
Colorado	3,750	1,970	5,720	New Mexico	610	420	1,030
Connecticut	1,320	1,990	3,310	New York	25,300	12,510	37,810
Delaware	280	610	890	North Carolina	4,040	7,820	11,860
District of Columbia	6,850	5,150	12,000	North Dakota	3,060	5,200	8,260
Florida	2,760	4,100	6,860	Ohio	23,600	15,510	39,110
Georgia	5,050	7,710	12,760	Oklahoma	5,020	10,260	15,280
Idaho	960	1,960	2,920	Oregon	1,590	1,330	2,920
Illinois	77,600	18,660	96,260	Pennsylvania	24,340	11,800	36,140
Indiana	7,400	8,390	15,790	Rhode Island	9,280	860	10,140
Iowa	3,460	7,210	10,670	South Carolina	1,480	2,770	4,250
Kansas	3,190	5,070	8,260	South Dakota	1,550	1,950	3,500
Kentucky	5,630	6,520	12,150	Tennessee	2,250	3,170	5,420
Louisiana	1,410	4,270	5,680	Texas	8,650	4,490	13,140
Maine	1,110	950	2,060	Utah	2,330	3,530	5,860
Maryland	37,760	9,470	47,230	Vermont	1,080	1,780	2,860
Massachusetts	17,750	3,080	20,830	Virginia	2,390	2,110	4,500
Michigan	33,670	6,600	40,270	Washington	4,070	7,070	11,140
Minnesota	4,240	7,210	11,450	West Virginia	1,670	1,480	3,150
Mississippi	2,110	3,440	5,550	Wisconsin	10,950	10,180	21,130
Missouri	16,590	21,450	38,040	Wyoming	1,680	350	2,030
Montana	230	1,470	1,700				
				Total	424,750	258,550	683,300

for construction of new water works systems be added to the Water Works Engineering estimate, a total amount of $830,000,000 is obtained, which figure is not far from the total of $803,300,000 estimated from the present inventory. On this basis and assuming a total population of 84,500,000 now connected with water works systems, the cost of the improvements, including water softening and construction of new plants, would approximate $9.50 per capita.

Methods of fulfilling needs

Under any general plan of water supply rehabilitation and improvement which may be envisioned at the present writing, the part to be played by the local water works departments and their state public utilities and health organizations would be the predominant one. Thus the local water works departments, thoroughly familiar with detailed local needs, would be in the best position to draft plans for needed additions and improvements to their

own water systems and likewise to supervise the construction work. Moreover, as public water works systems are to a large extent self-supporting and revenue-producing agencies, the local water works departments should be able, in a majority of cases, to handle the detailed financing of local improvements with such aid as might be necessary from state and federal governments. In some instances probably no outside aid, financial or otherwise, would be necessary, although experience has indicated that many desirable or even necessary water supply improvements, if left to the initiative of local authorities, sometimes are deferred too long under the pressure of local factional disputes and competition for funds for other improvement projects. Under these circumstances, the stimulus of state aid and educational efforts, backed by state laws and regulations, often is necessary. This is a proper and widely recognized function of state governmental agencies.

Before any water supply improvements can be undertaken, preliminary engineering surveys and detailed plans and specifications must be prepared, either by the water works department if it has the necessary technical facilities, or, otherwise, by private consultants with state aid and general supervision. It cannot be too strongly emphasized that these detailed surveys, estimates, plans, and specifications should be drawn up well in advance, so as to be ready when the time for action comes. Funds and personnel should be made available for this work without delay by appropriate action of the governmental and water works authorities concerned with this problem.

Construction of public water works systems, as well as additions and improvements to such systems, affords an ideal means of employment for a large and diversified group of individuals and industries. Water supply improvements are self-paying investments which add permanent assets to any community needing them. In the general scale of public works projects, whether for immediate postwar reemployment or for a long-range improvement program, water works always have merited and will continue to hold a very high place because of the essential nature of this utility and the widespread public benefits it bestows.

In financing water supply improvements, whether on a 10-year, a 20-year, or some other plan, funds usually are obtained through bond issues, repaid on some plan of amortization spread over short or long periods of time according to the policy and capital resources of the local water utility. In some communities many water works improvements are financed out of reserves accumulated from current water revenues, though this is the exception rather than the rule. In either case the cost of any construction program becomes, as a practical matter, one of planned annual expenditure over a term of years.

An approximate idea as to the annual payments which would be required to amortize a total capital expenditure of $683,300,000 for fulfilling the detailed water supply needs embraced by this inventory (exclusive of water softening) may be gained by application of the usual formula for liquidating a given capital sum by equal annual payments over any given period of time, at any assumed rate of interest. According to this formula, the annual payment (Y) required to liquidate a capital sum (C) in (n)

years with an interest rate of (r) per cent is $Y = C \times w$ where $w = [r/100] + [1 - (1 + \frac{r}{100}) - n]$.

For the purpose of illustration, let it be assumed that the period of annual payments was 20 years and the interest rate 3 per cent. On this basis annual payments of $45,930,000 as a rounded figure would liquidate a capital cost of $683,300,000 at the end of 20 years, including interest charges on annual unpaid balances. The yearly payments in this particular case would amount to 6.722 per cent of the original capital sum. In a similar manner, it may be calculated that annual payments of about $54,000,000 would liquidate a capital sum of $803,300,000, which would include the total estimated cost of water-softening in addition to the items covered in the inventory.

If the total economic loss due to present deficiencies in public water supplies be considered as amounting to about $50,000,000 annually and the improvements included in the present inventory were to result in the elimination of this loss, or a major part of it, the saving thus effected would go far toward repaying the total cost of the improvements by the end of 20 years or thereabouts.

A question may be raised as to the annual cost of operating the increased water supply facilities. Although this would be a definite and considerable item of cost, varying with the kind of added water service concerned, it would be spread among a large number of water consumers and would be readily absorbed in the general water service rates, as is customary in the ordinary operation of public water works systems. So far as the present estimates are concerned, it quite logically may be neglected for this reason, as constituting a legitimate item in the operating expense of a water system.

As the useful life of most water works structures ordinarily exceeds 20 years, this period would be a fairly safe one over which to finance improvements, such as are included in the present inventory. For parts of a water works system, such as distribution reservoirs and pipes and the more durable structures connected with intake, pumping, and treatment works, it is customary to figure useful life for as long as 30 or 40 years, though some features such as pumps and certain treatment equipment may become outmoded by functional improvements in design before the equipment has become worn out.

Aside from the economic savings which would tend to make water supply improvements self-liquidating, certain intangible benefits would result which in some cases probably would exceed any direct financial return. For the nearly 5,700 small communities which this inventory has revealed as having no public water systems, the intangible benefits of providing these communities with public water supplies would be almost incalculable if they could be expressed in terms of general improvement in health conditions and betterment of living conditions in the individual homes, resulting from adequate supplies of safe water delivered to taps and the installation of water-carriage systems of sewage disposal. The health benefits would affect in some measure the rural districts immediately contiguous to these communities, to which are drawn many people from these outlying districts for local trade. Experience has shown that many small communities, where favorably located, tend to undergo accelerated growth and indus-

trial development after being provided with public water supplies. A recent study in Florida and Georgia (10) has revealed that for industrial and residential areas the hardness of a water supply influences the rate of population growth, which is greater in cities providing softer water.

As to the extent of state and federal aid which would be required in order to carry out any extensive program of public water supply construction, and the manner in which such aid best may be applied, anything further than very brief comment seems beyond the scope of this paper.

Because of the revenue-producing character of public water supply systems, it would appear that Federal aid, if needed, could be limited very properly to capital loans at low interest rates, to be repaid through some plan of amortization such as has been illustrated above. One of the more outstanding needs shown by the present inventory has been the construction of new water systems for many small communities which have only very limited capital resources. In such instances it is quite possible that some form of state or federal aid would be necessary in order to initiate construction work on any comprehensive scale. In the case of small communities whose resources are not sufficient to permit the use of ordinary public financing through the sale of bonds, special loan arrangements probably would be necessary. Technical aid by the States in connection with the drafting of detailed plans and specifications would be needed in many such instances.

In view of the variety and large number of postwar reconstruction needs which may be expected to arise, many public works projects which in ordinary times would be highly desirable from the standpoint of the general public welfare will have to justify themselves as being of immediate economic benefit in order to obtain consideration. In some cases, public water supply improvements, when measured by this standard, will be found deferable. In other instances, however, they doubtless will rank very high in both immediate and long-range value as a public investment, on which a substantial and certain return is assured, both financially and otherwise. It would be a very wise provision for the future to make a careful survey of this matter during the war in order that meritorious water supply improvements may be identified in advance and detailed plans prepared for carrying them out at the proper time after the war. In this respect, the present inventory is only a preliminary step. It should be followed up by a systematic study of the more urgent water problems which must be solved within a reasonably short time in order to avoid possible injury or even disaster to the public health. Such a study may be commended to the various states, with full cooperation by the local communities and by the Public Health Service which has a large fund of specialized technical information on this subject at its disposal. It should not be delayed lest intelligent action, based on facts, be laid aside at a critical future moment in favor of hasty and ill-advised projects which may be unnecessary or, at best, unproductive of any substantial future benefits.

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References

1. *Manual of American Water Works Practice.* A.W.W.A., New York (1925), Chap. 1.
2. WEIBEL, S. R. A Summary of Census Data on Water Treatment Plants in the United States. Pub. Health. Rpts., **57**: 1679 (Nov. 6, 1942) (Reprint No. 2416).
3. HANSEN, PAUL. Active Problems in Water Purification. Jour. A.W.W.A., **30**: 1120 (1940).
4. Public Health Service Drinking Water Standards and Manual of Recommended Water Sanitation Practice. Publ. Health Rpts., **58**: 69 (Jan. 15, 1943) (Reprint No. 2440).
5. WHIPPLE, G. C. *The Value of Pure Water. In Biological Studies by the Pupils of William Thompson Sedgwick.* Univ. of Chicago Press, Chicago (1906).
6. SHAW, E. L., & CHASE, E. S. Economics of Water Purification. J.N.E.W. W.A., **52**: 131 (1938).
7. OLSON, H. M. Benefits and Savings From Softened Water for Municipal Supply. Jour. A.W.W.A., **31**: 607 (1939).
8. Water-Borne Outbreaks in the United States and Canada 1930–36 and Their Significance. Committee on Water Supply. Am. Pub. Health Assn. 8th Ann. Year Book (1937–38).
9. Post-War Waterworks Will Need Hundreds of Millions. W.W. Eng., **96**: 161 (1943).
10. MEES, C. A. Influence of Soft Water on Population Growth. W.W. Eng., **95**: 404 (1942).

Any water department that can use a supply of reprints of the paper *Watering Lawns* published in this issue of the Journal (pp. 330–333), should address inquiries or communications to the American Water Works Association, 500 Fifth Avenue, New York (18) New York.

A North Carolina Water Supply in 1766 *

THE Moravian Church, founded in Bohemia around 1458, is probably the oldest Protestant denomination in existence. In 1741 the Moravians settled in Bethlehem, Pa., and ten years later a small group of them banded together and braved the wilderness to North Carolina where they purchased 100,000 acres of land and called it "Wachau" or "Wachovia," ("wach," meaning stream and "aue," meaning meadow). There they built the village and church known as Betharaba. In 1766 they selected a site in the center of Wachovia and built a community settlement and named it Salem—the town of peace.

The following extracts from the various Salem Diaries give an interesting and, sometimes humorous, view of the planning and construction of a water supply system and of the ingenuity used to overcome the difficulties of that day. Labor trouble, charges of partiality, water rents and complaints of the lack of water are parallel with conditions today:

Aug. 1, 1773. A Committee was appointed to examine springs lying northwest of Salem and to see how the water from there could be be brought to the town.

Jan. 10, 1774. (A report separate from the Salem Diary). The Aufseher Collegium and the Water Works Committee met and agreed:

That work shall begin at the spring behind the Tan-Yard.

If possible, the water shall be taken to the top, or near the top, of the hill behind the Skin-house, where the first path from below comes into the road to "God's Acre," as from there all parts of the town and all the houses can be reached.

So far as possible the pipes shall be laid straight down and straight up the hills. We will try to find a sufficient number of black and white oak logs in the neighborhood, and when they have been bored they shall be washed in pools in the bottom near the Tan-Yard and in the Wach. Those leading the water downhill shall be bored larger than those leading uphill to give the water more pressure. . . . The bore shall not be over $1\frac{3}{4}$ in. The pipes leading to the houses can be smaller. Pipes shall not run through the lots, but along the streets, as it will cause complaint to have work done in lots that have been dug or planted. Pipes shall be 10 to 12 ft. long.

Mar. 18, 1776. Br. Krause took the water to the lower kitchen of the Sister's house.

Mar. 23, 1776. The pipeline was

* An historical account of the water supply systems of Salem and Winston, N.C. From extracts taken from old diaries of Salem and the Moravian Church, translated and published by Dr. Adelaide L. Fries, M.A., Litt.D., from *Memorabilia of Fifty Years* by the Rt. Rev. Edward Rondthaler, D.D., LL.D., and from Minutes of Salem and Winston Bd. of Comm.

brought into the kitchen of the Single Brethren.

——— *1777.* The inhabitants of the town have borrowed capital and joined in voluntary contributions to defray expenses, repairs, etc. (of another pipeline) so that Salem could be supplied from springs ½ mi. off.

Dec. 10, 1777. The Brn. Krause and Triebel are willing to undertake the bringing of the water in pipes to the town—the latter has agreed to cut and bore the pipes according to direction, and a contract will be made with him per yard.

Dec. 31, 1777. It was agreed with Br. Triebel that he should have 4 d. *Congress* money for each log he cuts for pipes and 2½ d. *Old* money for each foot bored.

Jan. 7, 1778. Br. Holland has offered to dig the trench for the water pipes for 2 shillings per rod; this was approved.

Jan. 15, 1778. We must pay $1.00 apiece for hauling logs, though six or eight can be brought at once; to such a height has the cost of hauling risen on account of the paper money.

Jan. 21, 1778. The trench diggers have several times asked for more pay, and it is agreed to give them 2 sh. 6 d. per rod.

Feb. 26, 1778. The ditch for the water pipes has been brought above the two-story house. Br. Krause again laid pipes; he had stopped for two or three days to turn gun barrels.

Mar. 9, 1778. Br. Krause brought the pipeline today to the well pump; there he put in a standpipe out of which the water ran.

Mar. 18, 1778. Br. Herbst reported that Br. Bagge had been very unfriendly and had said that partiality had been shown in the placing of the standpipe.

Mar. 21, 1778. Today the pipe water was brought into the kitchen of the tavern.

Mar. 23, 1778. The pipe water was brought into the kitchen of the Single Brethren, and this far-reaching work was brought to an end, so far as it was planned for this time.

Mar. 26, 1778. As the water has been brought in successfully and rapidly, the Collegium decided to give Br. Krause a present of *four silver dollars.*

July 8, 1778. The pipe water in town is rather weak, so the second spring shall be added to the first supply.

Dec. 16, 1778. Each person who contributes to other congregation causes shall pay nine pence each four weeks as water rent. Those who do not use the water daily shall pay the same amount, for it is a town enterprise.

——— *1778.* (From the Memorabilia)—Now in five places in the town, water runs from a pipe, for drinking and for other necessary purposes.

[The standpipes (Ständer), erected in 1778, have all disappeared, but the references in the Diary and Minutes (not all of which have been translated), together with the knowledge of the type which was in use for many years thereafter, give a fairly clear idea of how they were made and used.

From upright wooden pipes near the Skin-house and in the Square the water flowed constantly, the care of the overflow being the subject of numerous discussions prior to the building of reservoirs. The water from the Skin-house standpipe quickly wore a dangerous ditch across the main street and a pipe was laid to carry it; in the Square the overflow filled an open reservoir from which water could be

dipped in buckets. When first placed, these two standpipes were open at the top, for it is noted that the water rose higher from the pipe in the Square than from that at the Skin-house, but the top was doubtless plugged and the water delivered through a spout for convenience in filling vessels, as a barrel could be set there to fill overnight.

The standpipe at the Gemein-Haus had two spouts, one opening inside the Sister's kitchen and one in the yard. Those were doubtless provided with plugs to be used when water was not needed, for there is no reference to a surplus flow there, at the Brother's House or at the tavern. There is no explanation given of Br. Krause's plan for turning all the flow to one pipe in case of need, but to plug the vents usually open would turn all the water toward any spout from which the plug had been removed.

The system included a little pond near the "grinding mill" made by building a dam and spillway, and into it were rolled the logs not needed for the first lines of water pipe, so that they should not lie in the air and rot; the water in the pond was also an additional protection in case of fire, though it could be brought into use only by a bucket-brigade. *Translator's note.*]

Apr. 22, 1779. Br. Krause is to receive £5, *good money* per *year* for looking after the water works.

Feb. 1, 1780. A summary of the cost of the water works was presented, with the receipts and disbursements in 1779. Receipts were about £42:18:–, including £13:4:– in paper money. Expenses were £69:17:6, including £23:6:6 in paper money. . . . It is evident that the receipts have not exceeded the expenses, and this should be made known to the entire congregation, for then no one can object to the payment of 9 d. each four weeks, in good money.

Apr. 3, 1780. A standpipe was set in the water main opposite Br. Miksch's house and a barrel placed there for the accommodation of families on that side of the street, and also for the use of strangers.

Aug. 1, 1780. Persons living in the upper part of the town are complaining that since Stockburger has begun driving his cattle to the upper pasture, the cows drink from the trough from which cooking water must be brought, and it is very disgusting . . . we wish he and his cows were outside the town.

——— *1782.* (From the Minutes of Salem Board.) The water works were repaired, some improvements were made and the pipeline was somewhat extended. It is found that the bored logs which had been sunk in water three years before had not kept as well as had been expected, the ends having begun to rot, and it was decided that thereafter only a few logs should be kept on hand for quick repairs.

Repair Problems

Nov. 4, 1783. New pipes must be laid for the water works. It was decided that the holes in the present pipes are too large, and the new ones shall be 1½ in. A special auger shall be made, belonging to the Congregation.

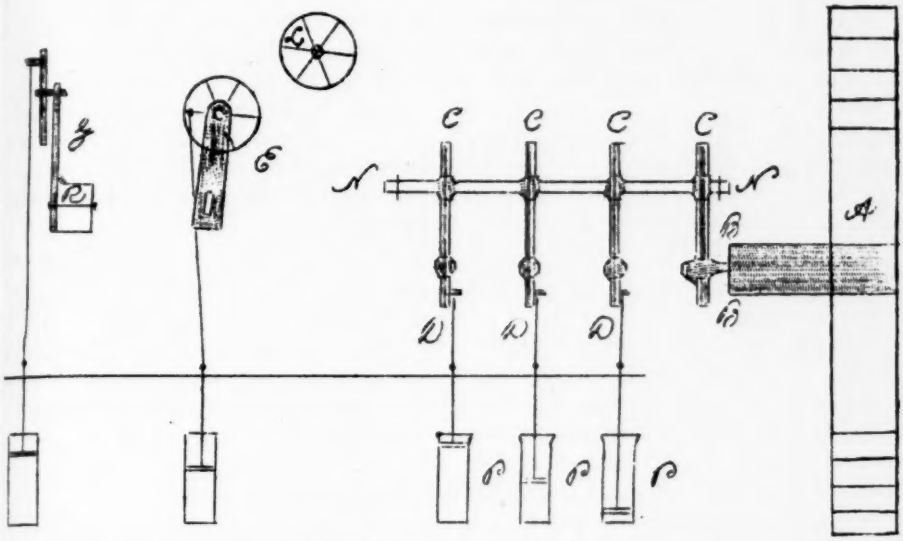
Jan. 21, 1784. The water standard at the tavern is frozen. It is highly important that each such outlet be protected. Straw is the easiest thing to use, but if there are cattle about, the straw should be covered with sacking. To pack it with horse manure is warmest.

When new water pipes are laid they should be placed deeper in the ground.

May 23, 1785. For eight days our pipe water has failed and today, after much effort, the leak in the pipe was found, for which all were glad.

Apr. 25, 1787. Tomorrow, in a workmen's conference, it shall be stressed that no one shall allow himself to be persuaded to make any change in the water works without the express permission of Br. Johann Krause.

Sept. 11, 1787. There is often complaint in town about the lack of water, especially on the day when the hat-maker washes his hats and families do their washing. The best help would be for the hat-maker to select a day when there is usually little washing done in the families.



Sketch From Original Drawing Wachovia Museum, Made by W. S. Pfohl.

FIG. 1. Plan and Explanation of the Pumps: (A) Shewing the Water Wheel (BB) the First Driving Wheels (CCCC) Shewing the 4 Wheels on Lying Shaft (DDD) the 3 Stud Wheels to Work the Pumps (PPP) the Pumps (E) Side View of Stud Wheel (G) Edge View of Stud Wheel (R) the Timber on Which the Stud Plate Must be Bolted. The Wheels Marked *D* Must be Bored 7¼ In. From the Centre for the Pump Stud. The Stud Wheels Should Have a Boss 1¼ In. Long on Each Side of the Wheel & the Six Wheels That Work the Pumps to be 1½ In. Face, 18 in. Diam. 1¼ Pitch—the First Driving Wheels 2½ Face 1½ Pitch, the One for the Water Wheel Shaft to be Bored 2 In. & a Groove Cut in Lying Shaft. From End to End, so as to Place the Wheel Anywhere We Want. (L) The Wheel on Lying Shaft. The Studs to be made of Cast Steel & Strong Enough for Three Horse Power. The Lying Shaft 3 Ft. 7 In. Long—3½ Bearing 1⅞ In. Diam. Contents of Bore of Pumps 3.14; Stroke of Each Pump 14.50; Cu. In. in Each Pump 45.57; Strokes of Pump Per Min. Aver. Speed 30; Cu. In. of Water Per Min. 1367.10; Cu. In. Per Hr. 82026. Reduced to Gal., Wine Measure, @ 231 Cu. In. Per Gal. Will Give 355 Gal. Per Hr. Pumped by 3 Pumps.

Sept. 21, 1789. The water in our water works becomes so scant that the town suffers for lack of it.

Dec. 1, 1789. Br. Lück will lay the new bored pipes through Holland's field. Iron boxes will be used. [The so-called boxes were iron collars,

sharpened on both edges. They were driven into the adjoining ends of the logs, making a tight joint.]

Jan. 7, 1790. Our water works were thoroughly repaired and so finally the repeated shortage of water has been eliminated.

May 31, 1791. President Washington visited our water works and gave his approval of them and the service it gives.

Sept. 26, 1793. Water works account shows a deficit of £10:12 caused by extensive repairs this year. Wooden collars have been replaced by iron.

Dec. 3, 1793. The water pipes at the Gemein-Haus and at the Sister's house fail often.

Dec. 25, 1802. Day before yesterday the leak in the old water pipes was found, and, as another spring has been added to the supply, the great lack has suddenly come to an end, and the choir houses and families are again bountifully furnished with water.

———— *1802.* (From the Memorabilia.) During the latter half of the year the shortage of water in Salem became not only troublesome but serious. This was remedied by taking to the pipes the water from another spring, though not a large one, and finally by the finding of the leaking water pipes, for which a long and vain search had been made. The whole town rejoiced and was thankful.

Oct. 27, 1803. The constant complaints about the pipe water show more and more that our water works are insufficient.

Mar. 18, 1806. In a newspaper we have seen the high praise of *clay pipes* for conducting water and we considered whether they could not be tried here. Br. Crist (the potter) wishes to get such a pipe from Charlestown-on-the-Ohio, where they are made, so that he can get a clearer idea of them, and will write about it to Br. Hockenwalder.

Aug. 21, 1806. The head spring of our water system has been failing more and more for some years, and finally gave out entirely, causing a serious lack of water. There was great joy in Salem a week or two ago when it was accidently found again a little further down the hill and as strong as ever.

Sept. 23, 1806. Br. Crist has made several earthenware pipes and will put them together so that we can see whether we can make a cement that will hold water.

Nov. 3, 1808. A summary of receipts and expenditures of the water works, May 1, 1807 to April 30, 1808. . . . It was mentioned that a trial was being made with four hundred clay water pipes, but only time would show their value. . . .

Change to Clay Pipe

The change from log water pipes to clay pipes was gradual during the time from the Diary entry of 1808 until the time when the northwest springs were abandoned, and may not have been a complete change. This is shown by an entry in the Diary on *April 25, 1842,* which suggests a change from the wooden pipes to iron pipes. (No definite steps were ever taken to make this change.) The entry is as follows:

"It was suggested that the town be provided by degrees with iron pipes in place of the wooden pipes hitherto used and, somewhere in the upper town, a large cistern might be placed, and then the other cisterns might be abandoned. This is a matter of importance and needs careful consideration and will be taken up later."

The Diary entry of *February 19, 1827,* gives an incident that might be termed "chiseling" today:

"Br. Shulz asks that the Superintendent of Water Lines, to whom the Superintendent of Congregation Business had given permission to cut logs for pipes on their (Salem) land, may do this at a definite time of year, and that the work be done only by one man appointed by them. Br. Shulz has received certain information that under the pretense of cutting logs for pipes, certain people have been cutting saw logs."

Remedy Sought for Water Shortage

Jan. 3, 1828. (Meeting of the Adult Brethren.) The chairman reported that, at the request of Congregation Council, the Aufseher Collegium had appointed a Committee to plan a remedy for the present great shortage of water in Salem, this Committee consisting of the Brethren John Leinbach, John Vogler, Isaac Boner, Jacob Blum, W. L. Benzien, Henry Herbst, and Theodore Shulz. Their report was read, which proposed to use the free spring at Br. Theodore Shulz' water works loading the water to his line and Br. Benzien's bottom garden, and there to build a house for an 18-ft. water wheel. From there the water can be taken in a direct line to a point in front of the house of Theodore Shulz, the highest place in town, and can from there be distributed. Iron pipes to be used from the wheel to the cistern.

To drive the water wheel, water shall be brought in a trough made of plank from the mill branch in Fockel's (Fogle) meadow, crossing the fields of Philip and the widow Blum: It is estimated that this will cost thirteen or fifteen hundred dollars. . . . It was agreed that the cost should be met by subscription and what more was needed should be borrowed on account of the water works.

The vote in favor of this proposal was unanimous.

Jan. 17, 1828. Br. John Vogler is fire inspector and superintendent of the water works.

Jan. 22, 1828. Collegium approves of borrowing $1000 on account of the water works from Gottleib Shober at 5 per cent for five years.

Aug. 18, 1828. The old water system has had another deficit, $91.88¼, and the (yearly) account shows a debt of $137.95¾, which will be taken over by the new water system, as the pipes, the borer, the borer bench and other tools will now belong to the new system and are a sufficient equivalent (for the old debt).

(From the Memorabilia 1828.) The new water works, begun last year to provide our town with good water in sufficient quantity from the nearby fine spring, was finished sooner than was expected and with unusual success, and experience shows that it fills the need entirely. The spring water is raised by three pumps, driven by water brought from a branch at some distance, and the water is delivered into a cistern at the highest point in the town and runs from there into the various pipelines. All the cisterns, from one end of town to the other, are plentifully supplied with water, and at a number of places where risers have been placed, the water is fresh for drinking even in the hottest weather.

Sept. 10, 1829. For a year and a day the water works have been in action, to the great advantage and convenience of the residents in the town. . . .

From 1828 until the forming of a private stock Company in 1887, this system (1828) probably was the only system used.

Jurisdiction of the State Corporation Commission

By H. Lester Hooker

THE State Corporation Commission was created by the Constitution of 1902, which was drafted by the Constitutional Convention that convened in 1901. It is doubtful that the extent to which the jurisdiction of the Virginia Commission extends and the powers with which it is clothed is generally understood. For this reason the author intends to dwell upon this at some length and in some detail.

Prior to the adoption of the Constitution of 1902, such regulation as existed in Virginia was under the old railroad commissioner and the Board of Public Works. Under the old system, the regulation of public service corporations and of their rates, service, etc., was in a more or less helpless state and conditions were chaotic. During this period the establishment of a rate for a public service corporation was a cumbersome and long drawn-out procedure. For instance, the railroad commissioner would prescribe a certain rate, and if the corporation for which the rate was prescribed did not wish to put it into effect, the commissioner was powerless to enforce the rate, and had to proceed through a circuit court in order to have the rate enforced. The matter was heard *de novo* in a circuit court with an appeal lying to the Virginia Supreme Court of Appeals, and then, in many cases, to the Supreme Court of the United States. A typical illustration of such procedure can be found in the case of *Southern Ry. Co. v. Commonwealth,* 98 Va. 758.

In view of such prevailing conditions, the framers of the Constitution sought long and diligently to place such conditions behind the people of Virginia forever, and it has been generally conceded that the most brilliant and difficult task performed by the Constitutional Convention of 1901–1902 was the framing of Article 12, dealing with corporations generally and providing for the State Corporation Commission as since constituted.

In creating the State Corporation Commission the Constitution of 1902 clothed it with administrative, legislative and judicial powers. At the time of the adoption of this Constitution the public service corporations bitterly opposed the exercise by one central body of such power, but the wisdom of this action has been recognized by the fact that many other states have adopted the same provisions.

The original functions and jurisdictions of the Commission, as embodied in the Constitution, include the issuing of all charters or certificates of incorporation and amendments thereof for

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domestic corporations; the granting of certificates to foreign corporations to do business in Virginia; the enforcement of the law in reference to the administration of foreign corporations; assessment for taxation, both state and local, of transportation and transmission companies, and the regulation of their rates, rules and regulations and service. Transmission companies include all telephone and telegraph companies.

Section 156(b) of the Constitution of Virginia confers upon the Commission the widest possible powers to supersive, regulate and control, and prescribe and enforce the rates and charges of all such transportation and transmission companies. This section also provides that the authority of the Commission to prescribe rates and charges for such companies shall be paramount.

Section 156(c) of the Constitution reads in part as follows:

In all matters pertaining to the public visitation, regulation or control of corporations, and within the jurisdiction of the commission, *it shall have the powers and authority of a court of record, to administer oaths,* to compel the attendance of witnesses and the production of papers, to punish for contempt any person guilty of disrespectful or disorderly conduct in the presence of the commission while in session, and to enforce compliance with any of its lawful orders or requirements by adjudging the enforcing by its own appropriate process, against the delinquent or offending company (after it shall have been first duly cited, *proceeded against by due process of law before the commission sitting as a court,* and afforded opportunity to introduce evidence and to be heard, as well against the validity, justness or reasonableness of the order or requirement alleged to have been violated, as against the liability of the company for the alleged violation), such fines or other penalties as may be prescribed or authorized by this Constitution or by law.

Section 3723 of the Code of Virginia, 1936, reads:

The commission, on hearing of all complaints, proceedings, contests, or controversies, in which it shall be called upon to decide or render judgment in its capacity as a court of record, *shall observe and administer the common and statute law rules of evidence as observed and administered by the courts of this Commonwealth, in like manner as complainants and defendants in the courts of this Commonwealth.*

Section 3902 of the Code of Virginia, 1936, in part reads:

Any person or corporation aggrieved by anything done or omitted in violation of any of the provisions of this or any other chapter under this title, by any public service corporation chartered or doing business in this State, shall have the right to make complaint of the grievance and seek relief by petition against such public service corporation *before the State Corporation Commission, sitting as a court of record. If the grievance complained of be established, the State Corporation Commission, sitting as a court of record, shall have jurisdiction, by injunction,* to restrain such public service corporation from continuing the same, and to enjoin obedience to the requirements of this law, *and the said commission, sitting as a court of record, shall also have jurisdiction, by mandamus,* to compel any public service corporation to observe and perform any public duty imposed upon public service corporations by the laws of this Commonwealth, subject as to any matter arising under this section to the right of appeal to the Supreme Court of Appeals by either party as of right in the mode prescribed by law.

An extensive discussion of the powers of the State Corporation Commission will be found in *Prentis v. Atlantic*

Coast Line Company, 211 U.S. 210. In this case it was held that the Commission is a court of record, but in matters pertaining to the establishment of rates and charges for transportation and transmission companies the Virginia Commission exercises a legislative and not a judicial function.

Mr. Justice Fuller in the case above referred to among other things stated:

> The Virginia State Corporation Commission was created and its functions, powers, duties, and the essentials of its procedure were prescribed in detail by the Constitution of the State as well as by statute. *It was made primarily a judicial court of record of limited jurisdiction, possessing also certain special legislative and executive powers. . . . Not only do the Constitution and laws of Virginia make the commission a judicial court of record by clothing it with all the attributes of such a tribunal, but they expressly declare it a court, and require it* to proceed only by due process of law and inquire into and determine every judicial question coming before it.

Mr. Justice Harlan in the same case made the following statement:

> *In my judgment, the Virginia State Corporation Commission is, in every substantial sense, a court.* It is shown conclusively to be such by the provisions of the Constitution and laws of Virginia, as interpreted by the highest court of Virginia and as summarized in the opinion of the Chief Justice. (Italics ours.)

The late Senator John W. Daniel, a member of the Constitutional Convention of 1901–1902 and very prominent in its deliberations, in his brief on behalf of the State Corporation Commission in this case had the following to say:

> The state corporation commission fulfills every definition and description of a judicial court ever given by any judicial expounder of, or any intelligent commentator on, the jurisprudence of the English-speaking peoples.

Section 155 of the Constitution contains a very pertinent, as well as a very important, provision, which reads as follows:

> The commission shall annually elect one of its members chairman of the same, and shall have one clerk, and such other clerks, officers, assistants and subordinates as may be provided by law, all of whom shall be appointed, and subject to removal by the commission.

It seems perfectly plain from the provision of the Constitution above quoted that its purpose is to obviate any possibility of outside involvement that might influence the selection of the employees of the Commission. It is obvious from a reading of this provision that the framers of the Constitution were fearful that outside influence might in some manner enter into the selection of the employees of the Commission, which might handicap the independent judgment of such employees in the performance of their public duties against the best interests of the public; consequently the Commission is clothed with full authority to appoint and remove its employees.

Also, Section 156(c) of the Constitution authorizes the General Assembly to vest the Commission with plenary power to prescribe and enforce rates and charges of all public service corporations other than the transportation and transmission companies mentioned above. Therefore, in pursuance of this authority in the Constitution, the General Assembly has, from time to time, greatly enlarged the functions and jurisdiction of the Commission to such a point that it is now conceded that the scope of this Commission's functions and jurisdiction is broader than any other like state regulatory body in the

United States. Among some of the duties added by the General Assembly since the creation of the Commission are the following:

1906—The Bureau of Insurance was created. At that time, the Commission's supervision and jurisdiction of its functions was very limited. The Commission was given the power to hear and decide appeals from the decisions of the Commissioner of Insurance. Under the administration of Governor Byrd in 1928, all the powers as to the regulation and supervision of insurance and banking were placed under the control of the State Corporation Commission. In 1910, there was created within the Commission a division known as the "State Banking Division," but as above set forth, under the administration of Governor Byrd, the departments of insurance and banking were combined into one bureau, entitled "The Bureau of Insurance and Banking" and the powers as to supervision and control thereof conferred on the Commission.

1910—The Commission was given the power to assess for taxation, both state and local, of light, heat, power, gas and water companies.

1914—The Commission was given the authority to regulate the rates and service of light, heat, power, gas and *water* companies.

1915—The assessment of car loaning companies.

1918—The administration of the Securities Act (Blue Sky Law).

1923—The regulation of motor transportation.

1924—The regulation of rates for pilotage in Virginia waters.

1928—(a) The regulation of aircraft transportation, landing fields, etc.

(b) The passage of what is commonly referred to as the "Water Power Act." It provides that in order to conserve and utilize the otherwise wasted energy from the waters in this state, it is by the Act declared to be the policy of the state to control the waters of the state and the utilization thereof to the greatest practicable extent, and confers the power of the administration thereof on the State Corporation Commission.

1930—All the powers and duties imposed upon the Secretary of the Commonwealth by the statutes in relation to corporations, both foreign and domestic, except those relating to his appointment as statutory agent by foreign corporations were transferred to the State Corporation Commission.

1934—(a) The State Corporation Commission was given supervision and regulation of the issuance of securities by all public utilities. (Public Utilities Securities Law.)

(b) Also, supervision and regulation of the relations and practices between public utility operating companies and affiliated service or holding corporations. (Public Utilities Affiliates Law.)

1938—There was created the Division of Aeronautics to take over the maintenance and construction of airports, formerly performed by the State Department of Highways, and the regulation of aircraft industry already performed by the State Corporation Commission. This department is expanding very rapidly and will have an important place in the field of future transporation.

During the period from 1914 up to about 1932, there were many formal proceedings before the Commission involving the reasonableness of the rates of these classes of public utilities. It is fundamental that public utility rates must be "just and reasonable," but

many of those who often use this phrase do not always appreciate the difficult task that is generally encountered when determining such rates in actual practice.

These rate proceedings were initiated in the great majority of the cases through (1) petitions filed by the utility companies, requesting adjustments in their rates, both as to increases and decreases; (2) petitions filed on behalf of the customers or rate payers, generally requesting that rates be reduced; and (3) orders entered by the Commission, in certain cases, upon its own motion. In all such cases, regardless of how initiated, reasonable notice must be given and also an opportunity must be given to all parties to be heard and an opportunity afforded to introduce evidence.

Therefore, such proceedings almost invariably involved long drawn-out and expensive rate hearings, requiring, in many instances, as long as a year or more, to present to the Commission the great amount of evidence through the witnesses. Usually much of this testimony was widely divergent, and quite often the views of various witnesses were in direct conflict.

After the taking of testimony had been completed at the hearing, the Commission would then have the difficult task of studying and analyzing hundreds, and often thousands, of pages of evidence and reach its decision as to the fair valuation (i.e., the rate base) of the property for rate making purposes, actually used and useful in rendering service to the public, and upon which a fair return was to be allowed after determining the proper and reasonable amount for operating expenses, taxes and depreciation.

Of course, in the determination of the reasonableness of the rates of a utility company, the proper rate base, upon which the utility is allowed to earn a fair return, should be ascertained first and generally is the most difficult question to determine. The proper rate base shall be the present fair value of all the property of the utility, used and useful in the performance of its obligations and duties to render service to the public.

It may be well to point out, as the Commission has in numbers of decisions, that the present value in many cases cannot be determined by accurate measurement nor can it be accurately calculated by any mathematical formula, but it must be obtained or deduced from ascertainable facts which either enter into present value as factors of varying weight, or have evidential value of varying weight tending to show what is the present fair value of the property as a whole.

Neither historical book costs, nor original costs, nor reproduction new costs under wholesale construction within an assumed construction period, nor estimated cost of reproduction new under piecemeal construction in accordance with construction history (commonly referred to as book costs appreciated to reflect current labor and material prices), is of itself present fair value or the sole measure thereof. Though all may be of evidential value in determining present fair value, if any of them be taken as a base from which to deduce present fair value, they must, to secure a result of approximately present fair value, be subjected to such modifications as other pertinent factors in the particular case may require.

During the year 1932 the Commission gave much thought to the possibility of developing some method that

would decrease substantially the need for expensive, long drawn-out, and, in many cases, time-wasting hearings; and yet at the same time give an effective and expedient process for the determination of reasonable rates and the establishment of better relations between the public, the Commission and the public service companies. After several months of consideration, the Commission devised a new policy or program for the investigation into the reasonableness of utility rates.

This new method involved the policy of entering into direct negotiations with the utility companies, which negotiations were to be entered into as a result of, and based upon, facts and information first obtained from appraisals and valuations of the properties and examinations and audits of the books of the companies made by the Commission's own representatives.

At that time the Commission had only a small engineering staff and no accounting staff as such. Therefore, before undertaking to get the approval of the General Assembly to increase the engineering staff and to establish a new accounting department, the Commission decided to initiate and try out this new policy by the employment, in January, 1933, of an outside firm to make an investigation into the valuations, operating expenses, rates, etc., of three of the major utility companies operating in Virginia. The information and data to be obtained for the Commission were to be such as would and could be used in formal rate hearings, should this be necessary.

When these investigations were completed and reports submitted, the Commission entered into negotiations with the respective companies and, as a result, substantial rate reductions in each case were agreed upon. Therefore, in 1934 the Commission obtained authority to enlarge its own engineering staff, and also to set up its own accounting department, and since that time the Commission's staff has been carrying on these investigations.

Since the inauguration of this new policy in 1933, the Commission has been able to negotiate and put into effect reductions in rates for public utility service companies amounting to a total of more than $6,000,000 on an annual basis as of the time they were put into effect, and without the necessity of expensive and long drawn-out formal rate hearings for which the public bears the expense. The total accumulated savings to the utility customers for the period from January 1, 1933 to date, as a result of the above annual reductions, have amounted to more than $20,000,000.

The Commission, therefore, has been very much gratified as to the results it has obtained through the inauguration of this new policy. It feels that a definite step was taken in reducing to a minimum the necessity for the expensive and time-consuming formal rate hearings, although a fundamental rate hearing, with all its technicalities and the presentation of a confusing mass of evidence, may, at times, be absolutely necessary.

In conclusion, it can be pointed out that other regulatory commissions of other states have, after investigation as to the procedure followed by the Virginia Commission, adopted the same policy. (*Editor's note:* All italics in quotations above are the author's.)

Small Water Works for Unincorporated Areas

By Garland S. Sydnor

THE original small water works, some of which were built more than 30 years ago, were co-operatively owned by the users of the water and actually had no one to maintain and service them on any regular basis. Usually one of the owners of the system who lived nearest the pump applied oil and grease and phoned for service when it was out of operation. There were no meters and each user of the water paid an equal portion of the cost of producing the water regardless of what portion he consumed. Needless to say, these systems could not be depended upon to furnish a continuous satisfactory water supply.

The current type of central water system, which is in reality a *small water works for unincorporated areas,* is unique in design, service and cost. The occasion for its development is the fact that the builder of a small unincorporated community is faced with some very real problems, one of which is a water supply and a sewage disposal for each house. In most cases these two services cannot be obtained on the same lot because of the contamination of the dug well water supply by either the sewer system of that lot owner or the sewer system of the adjoining lot owner.

The builder confronted with this difficulty sought the assistance of the state board of health. They recommended either water from a public supply or deep drilled wells, or a central sewage disposal system. In most cases the public water supply was not available, and when available the cost was prohibitive. The same thing can be said for the central sewage disposal system, which, if it had been built, still left the hazard of possible dry wells. The solution seemed to be the central water system. With the aid of the health department and the builder, we designed and constructed what is now known as a *small water works for unincorporated areas.*

It has been contended by some interests that these central water systems throttle the growth of a community. Actually, the community would never have come into existence without the central water system. Care has been used in the design of the system and the selection of materials to permit either of two final developments taking place within 25 to 30 years. In that time the community may have become closely built up and can, by virtue of the number of housing units per acre, absorb the cost of fire mains, hydrants and a fire department. On

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the other hand, the community may have grown very slowly, or it may have grown in an area with no increase in housing units per acre. In that event the original central water system and its additional units will serve adequately and it would be entirely proper to make the material replacements required.

These land contract central water systems are built without the necessity of selling bonds, levying special taxes, or making use of public funds. Their cost is completely paid by two groups, divided according to their interest—the organization which anticipates a profit from the operation of the water system, and the user who is served by the system. The unpleasant situation, created when a small public water works, built at the expense of the tax payers, is unable to reach one of the tax payers because of the location of his property, never arises.

Success of Central System

The central water systems possess flexibility beyond any other type of water supply. These systems can be constructed one at a time wherever they are required and each one is a complete unit in itself. Because of this feature it is possible to build a small water works on the central water system principle, starting at any point and working in any direction. There need never be any center of production, storage or distribution. This is in contrast to a large water works which must be built from the center of production, storage and distribution, towards the outer edges of the area served.

As a result of efforts in this field, principles of design; methods of production, storage, distribution and control; and inspection and maintenance services have been developed which make these central water systems unique in their ability to serve the users of the water.

It is believed that the success of the central water system is based on the use of drilled well water supplies; the best pumping equipment obtainable, properly adapted to the particular job to be done; the use of fireproof, masonry and concrete pump houses; the use of distributed closed concrete reservoirs and hydropneumatic storage; and completely looped distribution systems, with every connection metered and all production units equipped with master meters.

Demands on System

In building the central water system it must be borne in mind that the user has a right to expect water acceptable to the state board of health, and water delivered in sufficient volume and under sufficient pressure to take care of all drinking and normal domestic requirements; this condition must exist at all times. A central water system has to accomplish the service described with a minimum of capital investment and a maximum of safety within the limitations of the capital investment. It is possible only by very careful inspection and constant maintenance to eliminate service interruptions which would necessarily follow leaks or excessive waste of water. These can occur on a large system with a large surplus of production or storage, without service interruption. The additional production and storage, if added to the central water systems normal original cost, would make it impractical to build the system.

Several years ago we entered into a contract with the owner of a considerable number of lots, who wanted to

provide those lots with a satisfactory water supply. This agreement is a land contract or an agency agreement and runs with the land regardless of its owner. We put in just such a central water system as described and supplied originally only seven connections with water.

Later another subdivision was developed approximately two miles north of the one with the seven connections. This second unincorporated area involved building a central water system to serve 30 connections. Between these two systems five separate real estate projects were finally developed. A contract was entered into with each of these unincorporated areas to render the particular service that each of the areas required. In each contract rights-of-way were given to run water supplies out from or into the unincorporated area. The ultimate interconnection of all central water systems in reasonably close proximity was thus accomplished. When this interconnection was completed there were seven separate central water systems, each one protected by the reserved capacity of the other six systems. The whole is a *small water works for an unincorporated area.*

Growth Rapid

Some of these original unincorporated areas grew more rapidly than the others, and in those areas, near the point of additional use, was constructed another central water system unit complete with production, storage and control, and such additional distribution as was immediately required. Where several production units actually supply one central water system of one or more units, each unit is equipped with multiple pressure switch control. To this we have added multiple time-clock control. Thus, the best possible service is obtained from all the units of the system. Each production unit is forced to operate some part of the day —the large producers at peak-load periods, the small producers at off-peak periods and all units at any time that an unusual load occurs. No piece of standby equipment is allowed just to stand by.

In this area, which now covers north and south about two miles and east and west about a mile, there are approximately 800 plotted and recorded lots and as many more unplotted and unrecorded. There are actually 276 separate water service connections, 12 drilled wells, 10 complete automatic pump stations, 10 distributed storage units and several miles of looped mains. The whole system is completely metered.

The growth of the original central water system unit from a unit serving seven connections to three complete central water system units serving 96 connections, part of the 276 mentioned merits description.

The original Unit 1 was located on high ground in close proximity to the seven original housing units. An 8-in. diameter drilled well of reasonable depth in hard gray granite, was constructed. The tested supply was approximately 15 gpm. This well was equipped with the best type of piston pumping equipment, designed for a capacity approximately equal to the tested capacity of the well. The water from the pump was delivered to a 5000-gal. hydropneumatic storage tank, located above ground at the well site. The end of the tank and the pump unit and all the controls were enclosed in a cinder block house provided with a concrete roof, steel manhole and metal covered door. This unit served very

satisfactorily until the load reached about 20 houses. It would have taken care of probably 30 houses in the winter.

Anticipating the overload of Unit 1, which would result in unsatisfactory service to the users, Unit 2, located approximately ¼ mi. from Unit 1, was developed. It was hoped that at this point a considerable volume of water would be obtainable, and that the well at Unit 2 could be equipped with a turbine pump. Drilling began at Unit 2 and continued until the well reached a depth of approximately 600 ft. in hard gray granite. Again the volume of water developed was disappointing —about 15 gpm.

Storage Reservoir

During the time necessary for drilling this deep well the developer continued to increase his housing units and it was evident that the design of Unit 2 would have to provide greater peak-load capacity than that developed at Unit 1. Since the well at Unit 2 would not in itself provide the peak-load capacity, it was necessary to obtain it with additional storage. A large, closed concrete reservoir was built and the pump unit was selected so that the full capacity of the well could be delivered either to the distribution system under full distribution pressure, or to the concrete reservoir, with the controls of this pump so arranged that it could be stopped and started either by the water level in the reservoir or the water pressure at Unit 1.

To take care of the load—heaviest during the sprinkling period in the late afternoon in the summer—a large capacity booster unit was used. This booster takes water from the closed concrete reservoir and delivers it into the distribution system, with the starting and stopping of this pump controlled entirely by the water pressure in the storage at Unit 1. The electric control is so wired that whenever the booster pump runs the well pump or production unit also runs, and the production unit continues to run until the reservoir has reached the predetermined high water level. In this way the greatest possible volume of water is maintained in the reservoir at all times.

As a precaution against broken mains which would, under ordinary circumstances, waste all the storage facilities, an electric control was provided to retain in the closed concrete reservoir fully 33⅓ per cent of its gross storage. This means that as soon as the leak is repaired not only can the production units be used to recover pressure, but also the much greater capacity of the booster unit, drawing its water from the reserved storage in the closed concrete reservoir, can be used. At Unit 2 the reservoir was constructed of concrete and the pump house or pump room was made a part of that structure, using steel manhole covers and a tin-covered door, giving complete protection from fire.

Progress of Plan

Foreseeing further development of this particular area, construction of Unit 3 was begun. This third unit is located a little more than ¼ mi. from Units 1 and 2. In this instance another 8-in. drilled well, constructed in gray granite and carried to a very reasonable depth, produced the very satisfactory supply of slightly more than 30 gpm. Thus, use was made of a deep well turbine pump and a complete hydropneumatic storage system. This was tied into the distribution system covering Areas 1 and 2 as well as Area

3. The best type of water lubricated deep well turbine, a 100-lb. working pressure tank and complete automatic electric control, housing the unit in a cinder block structure with steel manhole, were used. The control is a pressure switch further controlled by the time clock circuit mentioned previously.

Later, in anticipation of the continued growth of this area, the fourth well was constructed. Unit 4 was never developed, however, as the war stopped virtually all construction. Therefore, the anticipated demand did not occur and the well is held in reserve for use after the war when general civilian construction can again continue. The capacity of the well was entirely satisfactory and Unit 4 will be a turbine pump with adequate combination storage.

The best water works in the world, small or large, will not run itself. We have found it necessary to have a full-time superintendent of water, with a full-time assistant, a service truck completely equipped with supplies and materials particularly adapted to the central water systems' needs. These central water systems are further protected by the whole of the Sydnor Pump and Well Company organization, which includes management, maintenance mechanics, drillers and construction personnel, all or part of which can function any time that it becomes necessary—during periods of normal operation or periods of extreme emergency.

One of the periods of extreme emergency occurred in January, 1943. The area around Richmond suffered from a sleet storm which the Weather Bureau reported to be the worst in 50 years. Nearly one-half the electric service in the city, and probably 90 per cent of the electric service in outlying areas, was disrupted. This power failure included the whole unincorporated area which makes up the small water works described. Six crews were put into the field to provide temporary water service. This service was obtained by opening the valves and using gasoline-driven production units and gasoline-driven air compressors to shift the distributed storage from one central water system area to another area as required. As a result of these efforts, no user in the area was without water service for a period greater than six hours, while the electric and telephone services of these same users, despite the unprecedented effort of both the electric company and the telephone company, were out for periods ranging up to ten days.

Each unit of a central water works is complete and independent, thereby making the whole system most dependable.

A small town in eastern Virginia, established more than 100 yr. ago and which contains about 40 houses, may be used as an example in citing the cost of a small water works. The dug wells in this area were going dry and sand and mud rendered some drilled wells unusable. A central water system was constructed, complete from the drilled well to the meter at the property line where the water supply was approved by the State Board of Health in sufficient volume and with satisfactory pressure to 36 users. The connection fee paid by the user averaged $175. The four or five houses which did not take the water service paid no connection fee and are not in any way obligated because of the advantages enjoyed by their neighbors. The water rate is approximately 50¢ per 1000 gal.

There are a great number of unin-

corporated areas containing a sufficient number of housing units located close enough together to permit the construction of a small central water system, and the small central water system will go to make up part of the small water works which the area as a whole needs.

Occupational Deferment Water Works Employees

THE Office of War Utilities has sent an administrative letter to all water utilities which outlines the procedure to be followed in obtaining deferment of *necessary* men in water plants.

This letter is being sent by the OWU to water works executives. Portions of it follow:

How to Proceed in Obtaining Occupational Deferments

"To obtain the cooperation of Selective Service in giving consideration to occupational deferment requests, it is suggested that each water utility

1. Survey its entire personnel to determine Selective Service status of men liable for military service and the probability of their replacement. The facilities of the local U.S. Employment Service, in addition to those of the water utility should be used to obtain replacements.

2. File Form 42A for each employee who qualified as a "necessary man." Do not wait until a registrant has been classified 1A before filing this form. Form 42A may be accompanied by affidavits or statements defining the nature of the essential activity in which the employee is engaged. Special emphasis should be placed upon water utility service to war industry or to other war-related activity.

3. File an appeal within ten days after a necessary employee receives notice of 1A classification.

In those cases where a water utility feels it has a justifiable case for deferment, in spite of rejection by the local Board of Appeals, the Office of War Utilities desires to offer all assistance possible. It is suggested that, if the utility desires, the facts of the case be referred to the Office of War Utilities at the same time an appeal is made to the State Director of Selective Service. In such cases prompt action is necessary and the following information should be supplied to the Office of War Utilities:

1. Employee's Selective Service classification and date of such classification; previous occupational classification, if any; age and marital status (pre-Pearl Harbor father or non-father).

2. Date of appeal and the vote (split or unanimous) of the Appeal Board.

3. Employee's occupation and detailed description of his duties, including skills and previous training.

4. The date of induction, if order to report has been issued.

5. The date of referral to the State Director and the date of his decision.

6. Complete explanation of employer's effort to train, upgrade, or obtain a replacement. It is the employer's responsibility to exhaust every possible effort to replace men liable for military service under the law.

The action of principal value which the Office of War Utilities may take when convinced that the utility has presented a justifiable request for deferment is the certification to National Selective Service Headquarters that the employee is a necessary man in an essential industry. Such certification would carry with it to the Selective Service Headquarters the weight of judgment of an impartial governmental agency."

February 15, 1944

Tests for Active Residual Chlorine and Chloramine in Water

By Francis J. Hallinan

THE disinfection of water by chlorine involves a complex group of reactions whereby chlorine is consumed, reducing matter is oxidized and bacteria are destroyed. It is the duty of the water works operator to treat the supply in such a way that, when these reactions are substantially completed, there remains in the water a slight excess of chlorine or a greater excess of chloramine. The residual chlorine value obtained with methods of analysis in general use may represent active chlorine, less active chloramine, or non-bactericidal oxidizing agents—nitrites, oxidized manganese or oxidized iron. Simple specific tests for active chlorine and chloramine are needed to safeguard the sanitary quality of public water supplies.

The unique characteristics of sodium arsenite * as a reducing agent when used with ortho-tolidine make it possible to measure separately chloramine and active chlorine.

A paper presented on October 1, 1943, at the New York Section Meeting, Binghamton, N.Y., by Francis J. Hallinan, Jr. Analytical Chemist, Div. of Labs. and Research, New York State Dept. of Health, Albany, N.Y.

* Sulfamic acid, potassium antimony tartrate, and potassium bromide have selective action approaching that of sodium arsenite.

Determination of Chlorine and Chloramine

Chlorine

The ortho-tolidine-arsenite (OTA) test for active chlorine is outlined in Diag. 1. Sample A is treated with ortho-tolidine, which reacts instantly with the active chlorine. Arsenite is added at once; this reagent reduces the chloramine before any significant color reaction with ortho-tolidine takes place but it does not influence the reaction of the reagent with any nitrite, iron or manganese that may be present. Control B is first treated with arsenite to reduce chlorine and chloramine; then with ortho-tolidine. The resultant color is due principally to reaction of ortho-tolidine with nitrite, iron or manganese. The bottles are arranged in a comparator as shown, the color standard in line with B; this standard represents the active chlorine and is selected to compensate for the difference in depth of color between A and B.

Accurate compensation for natural color and turbidity is assured by this method, since any effect on them produced by the reagents is identical for the sample and for the control. Color comparison may be made at any time within five minutes; preferably it should be made after two minutes.

DIAGRAM 1

Determination of Chlorine

Light Source

(North light or light from a fluorescent daylight lamp diffused by transmission through opal glass or by reflection from a matte surface)

Distilled Water	Color Standard
	Chlorine
Sample A	Control B
1. Ortho-tolidine 2. Arsenite	1. Arsenite 2. Ortho-tolidine
Chlorine Nitrite Iron Manganese	Nitrite Iron Manganese

A — B = Color Standard

Observer

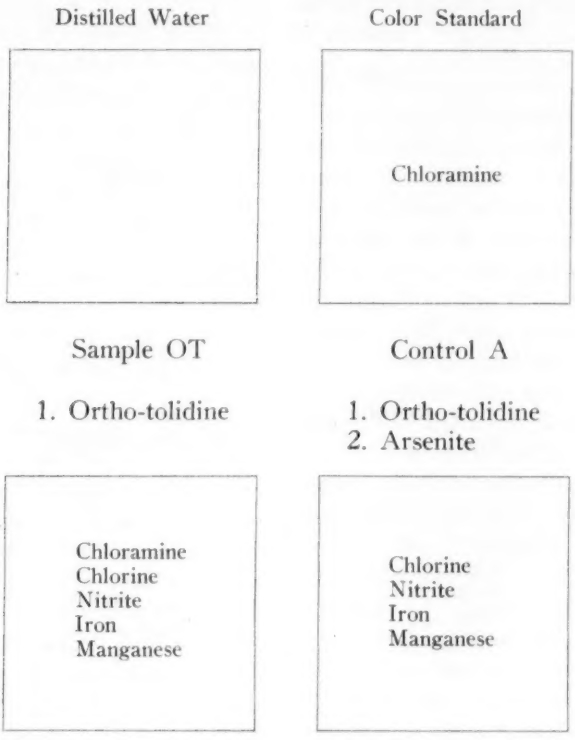
(Each block represents a 2-oz. French square bottle containing 50 ml.)

DIAGRAM 2

Determination of Chloramine

Light Source

(North light or light from a fluorescent daylight lamp diffused by transmission through opal glass or by reflection from a matte surface)



OT — A = Color Standard

Observer

(Each block represents a 2-oz. French square bottle containing 50 ml.)

Exposure of treated samples to light should be kept at a minimum.

Chloramine

The OTA test for chloramine is outlined in Diag. 2. The sample, OT, is treated in the usual manner with ortho-tolidine which reacts with any chloramine, active chlorine, nitrite, iron or manganese present. The control A, identical with the sample in Diag. 1, is treated at once with ortho-tolidine, then with arsenite. Cold samples should be warmed to room temperature after adding all reagents. The color in A is due principally to the reaction of ortho-tolidine with any active chlorine, nitrite, iron or manganese present. The color of the standard is then equivalent to the chloramine. Colors should be compared when at their maximum values, usually after five to fifteen minutes. Exposure of treated samples to light should be kept at a minimum.

TABLE 1

Effect of Arsenite on Color Reaction Due to Chlorine

Chlorine Concentration (OT)	Color Value*		
	OT Test†	OTA Test	Ratio
ppm.			OT/OTA
0.013	12	11	1.09
0.025	27	31	0.87
0.085	88	87	1.01
0.17	194	200	0.97
0.39	420	420	1.00
0.85	907	900	1.01
1.7	775*	790*	0.98
3.1	980*	1000*	0.98
0.2‡	206‡	202‡	Avg. 1.005§

* Comparisons were made in a 4-cm. cell and with a blue filter of the Klett-Summerson colorimeter; in the exceptions noted, a 2-cm. cell was used.

† Values have been corrected to represent 3 per cent dilution of sample, the dilution in the OTA test.

‡ Averages of 9 observations.

§ Weighted average of 17 observations.

Procedure

1. *Reaction Vessel and Sample Volume:* Two-ounce French square bottles of clear, colorless glass; 50 ml. of sample.

2. *Reagent Dispenser:* The standard medicine dropper of about 0.75-ml. capacity supplied with these bottles was chosen as the simplest dispenser of a fairly definite volume at the required speed, one of which is used wherever addition of either reagent is specified.

3. *Ortho-tolidine Reagent:* The standard reagent (1a) was used.

4. *Arsenite Reagent:* A concentration of 5 g. per liter of sodium arsenite was selected to permit maximum reduction of chloramine without diminishing the amount of color developed by ortho-tolidine with chlorine.

5. *Color Standards:* The provisional standards for field use (1b) were employed. A 2 per cent constant error due to differences in degree of dilution of the samples by reagents in the calibration of OT standards and in the OTA test may be compensated for by an equivalent dilution of the standards.

6. *Effect of Arsenite on Color Due to Chlorine:* Comparative OT and OTA determinations show no difference in color developed with ortho-tolidine by chlorine due to addition of arsenite (Table 1).

7. *Effect of Low Temperatures:* OTA values of chlorinated waters, natural or distilled, remained unchanged when the samples were heated to room temperature from 2° to 4°C. Temperatures above 20°C. are essential for complete color development with chloramine within the specified reaction time.

8. *Test Kits:* Commercial test kits have been investigated sufficiently to show that the OTA tests may be adapted for use with those that provide for a compensating cell of untreated sample.

Differentiation of Chlorine From Chloramine

The reaction of arsenite with chloramine, on which this test is based, is not complete. Thus there is a possible error in the determination for active chlorine and a small, but definite, error in the test for chloramine, i.e., in stable solutions of chloramine, from 0 to 3.5 per cent of the total value reacts as active chlorine. If this is a false residual it would appear negligible in plant control. This incomplete reaction also limits the range of chloramine concentrations that may be examined for active chlorine to 25 ppm. in terms of chlorine.

In the test for chloramine, the control A compensates for about 7 per cent of the material sought, i.e., results are about 7 per cent low.

The 5-min. reaction period is sufficient for substantial completion of the chloramine-OT color reaction with the usual concentrations, but periods up to 15 min. may be necessary with high residuals. It should be noted, however, that products of the reaction of chlorine with organic matter, particularly amines, may be included in the chloramine estimate.

Effect of Interfering Agents on OTA Tests

The limiting concentrations of interfering agents and of chlorine that may be examined by the OTA test are interdependent, i.e., the ortho-tolidine that reacts with any one is not available for reaction with the others. Also, some decrease in precision occurs when a large proportion of the total color is due to these materials. The simplest way of presenting these limits appears to be in terms of the maximum concentration of each that may be present in the absence of any of the others.

Chlorine	3 ppm.
Chloramine	3 ppm. in the test for chloramine
	25 ppm. in the test for chlorine
Nitrite	A saturated solution of sodium nitrite
Iron	25 ppm. when present as ferric chloride
Manganese	2.5 ppm. as colloidal manganese dioxide

Within these limits no false residuals were observed; compensation was complete with the exceptions noted for chloramine.

Control of Chlorination

Many raw waters that are sources of public water supplies were chlorinated in the laboratory. In a few instances, after ten minutes, the conventional 0.2 ppm. residual found with the OT test was also obtained using the OTA test for active chlorine. A considerably larger number of waters contained enough ammonia or organic matter so that this residual was chiefly chloramine or other chlorine reaction products and would not appear to be an adequate excess for disinfection according to present standards (2, 3). A very few waters contained interfering agents in such concentrations that no effective control with the OT test would be possible.

The chlorine doses used extended to the super-chlorination range; the residuals shown in Fig. 1 are for a 30-min. period of contact. The dose should be adequate for the substantial

oxidation of ammonia and organic matter, and such that any residual chlorine will be principally in the active form.

From these curves it appears that, while some active chlorine is found in the presence of chloramine, the amount is very small. If the dose is adjusted to maintain 0.2 ppm. of active chlorine after 30 min., super-chlorination would be insured even for some heavily polluted river waters. The OTA technic has definite advantages over the flash test (4) as regards ease of color comparison and specificity. The average ratio of a series of 63 flash tests, read at fifteen seconds, to the corresponding OTA test in the range 0–2.2 ppm. chlorine on 10 different water samples was 1.06, indicating substantial agreement.

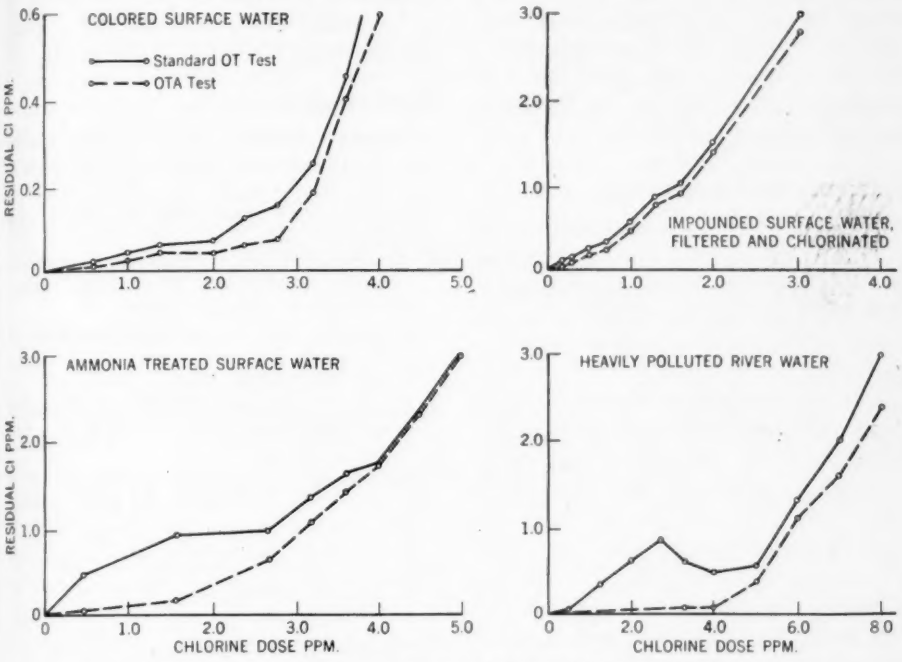


FIG. 1. Comparison of Ortho-tolidine and Ortho-tolidine-arsenite Tests for the Determination of Chlorine Demand.

Adaptation of the OTA Test to the Conditions Proposed by the Committee on the Control of Chlorination

The chemical reactions on which the OTA tests are based are applicable not only under the test conditions described in this paper but also to those proposed by the Committee on the Control of Chlorination of the American Water Works Association (5). In adapting the tests to the conditions proposed by the committee, the arsenite concentration in the treated sample may be varied considerably for convenience in dispensing. Thus, the 0.75-ml. amount used in 50-ml. test portions may also be used in 10- or 15-ml. test portions, if desired. The dilution error would, of course, have to be calculated for the conditions se-

lected. The proposed procedure has some advantage of precision in the method of adding sample to reagent, because of the effect of variations in agitation on the false residual with suspended iron or manganese. With two reagents, however, this technic requires a considerable amount of glassware. Another value of the proposed method of the committee is the short reaction period—5 min.—required for maximum color development with chloramine. There are slight changes in the limits for interfering agents depending upon the exact details of the technic selected.

Summary and Conclusion

A simple ortho-tolidine-arsenite (OTA) field test for residual chlorine and one for chloramine, applicable to concentrations that are likely to be encountered in the treatment of water are described.

No false residual chlorine values were observed with colloidal manganese dioxide up to 2.5 ppm. Mn, ferric chloride up to 25 ppm. Fe and sodium nitrite up to a saturated solution. With chloramine up to 25 ppm. (in terms of chlorine), the OTA chlorine residual was a negligible proportion of the total.

Application of the tests to plant control appears feasible with various types of waters chlorinated in the conventional manner. Control of superchlorination would be simplified, since treatment could be defined in terms of a minimum OTA residual for a particular water.

References

1. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn., New York (8th ed., 1936) (a) 20, (b) 232.
2. Streeter, H. W. Progress Report on Studies of Water Chlorination. Jour. A.W.W.A., **35**: 421 (1943).
3. Costigan, Stella M. A Bacteriologist Looks at Chlorine. Jour. A.W.W.A., **34**: 353 (1942).
4. Laux, P. C. Break-Point Chlorination at Anderson. Jour. A.W.W.A., **32**: 1027 (1940).
5. Control of Chlorination, *Committee Report.* Jour. A.W.W.A., **35**: 1315 (1943).

Conditioning Water for Steam Production

By F. H. Long

FOLLOWING is an outline of experiences in water conditioning for high-pressure boilers which have occurred at four different stations of the Wisconsin Electric Power Company. Two general types of operation are included, namely, production of steam for electrical generation only and production for a central heating load with by-product electrical generation.

Lakeside Station

Seventeen years ago, one of the world's first boilers operating at 1,300 psi., was installed at Lakeside. It is a Stirling type reheat boiler, with a normal rating of 250,000 lb. per hr. and 725°F. steam. It supplies a 7,700-kw. topping turbine, the exhaust of which is reheated for supplying the 300-psi. turbines.

The system was originally designed so that the feed water should consist of condensate only with losses supplied by condensate from the low-pressure section. Therefore, few, if any, problems in water conditioning were expected.

Within a few months after operation began, however, tube failures occurred due to internal scale formation. This trouble was soon corrected by reducing the excessive condenser leakage to a minimum, and the continued use thereafter of phosphate in the boiler water. It was fortunate that the use of phosphate for scale prevention was coming into general use after preliminary experimental work at the Bureau of Mines.

Only a few weeks after correcting the scale trouble, more tubes failed due to corrosion by dissolved oxygen in the feed water. Obviously, the former scale had protected against corrosion. Eliminating the dissolved oxygen, as much as possible, by mechanical improvements, and final scavenging with a continuous feed of ferrous hydroxide into the feed water, corrected this problem.

The importance of avoiding even a trace of dissolved oxygen was evident, and it was necessary to provide a simplification of the standard procedure (1) so that the operator could make a determination requiring only two or three minutes time.* From then on, the practice of taking routine hourly

A paper presented on October 19, 1943, at the Wisconsin Section Meeting, Milwaukee, Wis., by F. H. Long, Chemist, Wisconsin Elec. Power Co., Milwaukee, Wis.

* In the method described, a subsequent improvement in starch stability was obtained by heating the solution for one-half hour at its boiling point, cooling and adding a few ml. of chloroform per liter. Greatly improved thiosulfate stability was obtained by the addition of a few ml. of chloroform per liter.

tests of the feed water for dissolved oxygen and excess scavenging agent has been followed on all subsequent high-pressure installations with this company.

As so often happens, however, the corrective measures required for scale and corrosion prevention created a new problem, namely, turbine clogging. The old standard of high alkalinity for scale and corrosion prevention and a 3 to 1 sulfate ratio for embrittlement protection caused rapid reduction in capacity of the high-pressure topping turbine because of excessive boiler water carry-over.

After about six months of this unsatisfactory operation, sulfate was eliminated and reliance was placed on phosphate for embrittlement protection, based on experimental work at the University of Illinois (2). This step alleviated the turbine clogging to a great, but not sufficient, extent.

Reduction of caustic soda to zero by maintaining the equivalent phenolphthalein alkalinity as trisodium phosphate was next attempted, with no resulting improvement. Apparently the increase in PO_4, necessary to maintain the same phenolphthalein alkalinity, caused as much carry-over as the original NaOH.

Finally, the total phenolphthalein alkalinity was reduced to the point where the turbine remained clean indefinitely. This low alkalinity was, of course, radically below the American Society of Mechanical Engineers' suggested value of 250 ppm., but the industry already was beginning to question the efficacy of the boiler water rules based on earlier low-pressure operation.

The effectiveness of the above measures is reflected in the fact that three similar boilers at Lakeside operated under like conditions for seven years before any change in treatment was made. No tube failures have ever occurred, and no tube has ever been turbined on these boilers with a total of about 40 boiler-years of service.

The soft phosphate scale, which appears to be common to the phosphate treatment with low alkalinity, has never been present. This is attributable, no doubt, to the fact that the amount of ferrous hydroxide used as an oxygen scavenger is about ten times the amount of alkaline earth phosphates formed from raw lake water entering the feed water by condenser leakage. The ferrous hydroxide may act merely as a diluent of these phosphates or may have a flocculating effect.

The following analysis is typical of the boiler water maintained for the seven years from 1931 to 1938:

		ppm.
Sodium hydroxide		16
Trisodium phosphate (anhyd.)		65
Sodium sulfate		25
Sodium chloride		4
Silica		2
Suspended matter (Fe_3O_4)		200
Equivalent alkalinity as $CaCO_3$	P.	40
	M.O.	60
pH at 77°F.	Approx.	10.5

A low alkalinity was believed to be conducive to corrosion because the higher temperature caused an increase in the dissociation constant of water. Practical results, however, have shown no ill effects; in fact, under certain conditions, the opposite is true.

The first change in the above boiler water conditioning, made after seven years, was based on results obtained at Port Washington which dictated a further reduction in alkalinity, resulting in the entire elimination of sodium hydroxide, the phenolphthalein alkalinity being maintained only by the presence of trisodium phosphate.

The resulting phenolphthalein and

methyl orange alkalinities consisted of the following mixture in the boiler water:

	ppm.
Trisodium phosphate	40
Disodium phosphate (anhyd.)	20
Equivalent alkalinity as $CaCO_3$—P.	12.5
M.O.	32.5
pH at 77°F.	10.2

This latter reduction in alkalinity has resulted in appreciable coal savings as a result of decreased deposits in the low-pressure turbines receiving steam from the high-pressure boilers. At the present time the saving probably amounts to 1 per cent or nearly 10,000 tons of coal per yr. for Lakeside alone.

Recent work with the embrittlement detector, reported by the Bureau of Mines, indicates that the maintenance of phenolphthalein alkalinity with trisodium phosphate in the absence of caustic soda does not cause embrittlement. This has no direct bearing on turbine clogging, but does indicate another reason for elimination of caustic soda.

Fortunately, no other water conditioning problems have developed with the Lakeside equipment. Deposits in, or corrosion of, pumps and heaters have never occurred. The feed water has a specific conductivity of about 3 micromhos resulting from the presence of about 0.1 per cent condenser leakage and from traces of carbon dioxide and ammonia. It has a pH value of 8.8 at 77°F. Ferrous hydroxide is fed into the feed water continuously at the rate of about 1 ppm.

Port Washington

Because of the good success in water treatment at Lakeside, similar practices were followed when the first unit was installed at Port Washington. This also is a reheat unit, having a maximum capacity of 690,000 lb. per hr. at 1,300 psi. and 850°F. superheat and reheat. It supplies an 80,000-kw. turbo-generator.

Five stages of extraction heating raise the feed water temperature to 400°F.

The make-up of about 0.5 per cent is evaporated. It is required mostly for soot-blowing and blowdown.

Improved condenser design makes possible a very low rate of raw water leakage—a few thousandths per cent—and good performance gives only a few thousandths milliliter of dissolved oxygen per liter in the condensate. With these almost ideal water conditions, trouble would hardly be anticipated but, after one year of operation, screen tubes across the bottom of the furnace began to fail from corrosion.

From the appearance of the failures, oxygen in the feed water did not seem to be the cause, but there was no other apparent reason. It was finally decided, however, to approach the problem by making all conditions as favorable as possible from the standpoint of water conditioning and furnace heat transfer distribution. Thus, by correlation of the amount of hydrogen in the steam, a reduction in alkalinity and ferrous hydroxide scavenger was found desirable, since the amount of hydrogen decreased in proportion to their independent reduction and was thus assumed to be an indication of a reduced rate of corrosion. Ferrous hydroxide itself will produce hydrogen by decomposition of water above 400°F. (3).

Partial external insulation of the screen tubes, to reduce the rate of heat transfer to the tops of the tubes where corrosion occurred, was accomplished by not removing the ash which normally accumulates.

Several similar cases occurring throughout the country indicated that circulation and heat transfer conditions resulting in so-called steam-blanketing were conducive to corrosion. Furthermore, at the University of Illinois, attempts to simulate the corrosion pattern by laboratory experiments showed the deleterious effect of caustic soda under conditions where steam-blanketing was present.

To prevent steam-blanketing, the boiler manufacturer placed a sheet-metal spiral inside of each screen tube along the corrosion zone to break up the segregation of steam and water. This principle was first used at another station in the East, and was also used in the second Port Washington unit. A combination of the above remedies has reduced the rate of corrosion to at least an immeasurable amount. During each regular semi-annual inspection of the boiler, the screen tubes have been checked with an external electrical thickness gage developed for the purpose of determining the rate of corrosion.

Aside from corrosion, there have been no other major difficulties in water conditioning at the Port Washington station.

Although turbine clogging has never been a vital problem, turbine inspections do show a very slow deposition of silica, especially near the 300°F. temperature zone. This deposit occurs in spite of the low boiler-water concentrations which are as follows:

		ppm.
Trisodium phosphate		20
Disodium phosphate		40
Sodium sulfate		25
Sodium chloride	(Approx.)	3
Silica		2
Suspended solids		0
Equivalent alkalinity as $CaCO_3$—P.		6
Equivalent alkalinity as $CaCO_3$—M.O.		25

Tests for steam purity have been as low as 0.06 ppm. by the conductivity method. Better purity hardly could be expected but obviously it does not nullify the mechanism of deposit formation. Recent widespread work on this problem (4, 5) has indicated that boiler-water salts are appreciably soluble in steam, especially with high temperatures and pressures, and that deposition occurs by crystallization from the steam as it expands to lower temperatures and pressures in the turbine.

The solution of this problem, therefore, depends on affecting the solubility relationship or by interfering in some manner with the mechanism of crystallization. There is already hopeful evidence of possible methods.

East Wells Street

At the East Wells Street station, one 3-drum, bent-tube boiler, having a capacity of 220,000 lb. per hr. at 640 psi. and 825°F., supplies a 13,700-kw. non-condensing turbine, which exhausts at from 5 to 25 psi. into a central heating system. An auxiliary condenser is provided for emergency electrical load operation when the central heating demand is less than turbine full-load capacity.

None of the condensate from the central heating system is returned. The feed water consists of 22 per cent condensate derived from feed-water stage heaters. The remaining 78 per cent is city water make-up, treated by a hot process lime-soda softener, clarified by calcite filters and adjusted with sulfuric acid. The acid serves to prevent carbonate after-deposits in the feed-water heaters—the final feed-water temperature being 350°F.

Hagan phosphate adjusted with caustic soda is fed continuously into the upper front drum of the boiler.

Softener

The hot-process softener is an integral de-aerating type, with steam atomizing de-aerator at the outlet exhausting to a spray-type heater in the softener inlet chamber. It has a maximum rated capacity of 266,000 lb. per hr. (32,000 gal.) and a normal rating of 200,000 lb. per hr.

To obtain low hardness and the maximum removal of silica, the lime and soda ash are adjusted to give the following alkalinity at the filter outlet:

	ppm. (as $CaCO_3$)
Phenolphthalein alkalinity	23
Methyl orange alkalinity	36
Hardness	15
pH at 77°F.	10.5

Due to the relatively large proportion of magnesium in Lake Michigan water, the silica is reduced from its initial 3 ppm. to 1 ppm. (and sometimes lower) at the filter effluent; this is very desirable from the standpoint of preventing silica deposits in the turbine.

pH Control

An unusual feature is the automatic control of the sulfuric acid feed which is direct-connected to the main flow of softened water without any intervening mixing chamber.

The 1 per cent solution of sulfuric acid used for this purpose is prepared from 66° Bé commercial acid, in a lead-lined supply tank. From this tank the dilute acid is pumped through a lead line to the outlet of the calcite filters. The connection is made just a few feet from the suction of the transfer pump which discharges the acid-adjusted water into the suction of the boiler feed pump and surge tanks.

The acid flow is regulated with a rubber-lined Saunders patent valve actuated by an air-pressure diaphragm. A dual combination water flowmeter and glass electrode pH recorder controls the air pressure which actuates the diaphragm in accordance with variation in the treated water. In this manner a very close regulation of pH value is obtained over the whole load range of softener operation.

Since the acid is used primarily for the prevention of heater deposits, its effectiveness is readily determined by the terminal temperature differences of the heaters.

The amount of acid required is approximately 15 ppm., which reduces the pH value from 10.5 at the filter outlet to 9.7 after the acid injection.

Boiler-Water Control

Boiler-water concentrations are uniformly maintained by manual adjustment of the continuous blowdown in accordance with changes in the treated water flow. Ten per cent blowdown is ordinarily maintained.

Flexibility in phosphate and alkalinity control is inherent in the principle of direct feed to the boiler drum.

Because of the relatively moderate amount of hardness in the feed water, a considerable amount of soft phosphate scale forms on surfaces of low steam generation, such as the downcomer tubes in the rear bank. This tendency is increased with lower alkalinities.

Some observers claim that a sufficiently high alkalinity will avoid the difficulty by precipitating magnesium as the hydroxide even in the presence of phosphate. It is believed, however, that the higher causticity required would be undesirable from the standpoint of turbine blade deposits and caustic embrittlement, although the latter is much less a factor now that

nitrate has been found to be an inhibitor. As to turbine blade deposits, they have been negligible under the present conditions and it has not appeared desirable to risk transferring any trouble from the boiler to the turbine by raising the alkalinity.

Commerce Street

This boiler is a 3-drum, bent-tube type, 375,000 lb. per hr. maximum and normal capacity, at 1,300 psi and 900° F. It supplies a 35,000-kw. condensing turbine from which a variable percentage of steam up to 60 per cent maximum is bled off for the central heating system. There is no condensate return from the heating system. The required make-up water is externally treated with a carbonaceous zeolite softener.

The softener effluent, after degasification at approximately 80°F., mixes with the turbine condensate at the suction of the condenser hot-well pump. From there on, the layout is along conventional lines. Four stages of extraction heating provide a final feedwater temperature of 400°F.

Dissolved oxygen, which at the condenser and degasifier hot wells is less than 0.02 ml. per liter, is reduced to zero by scavenging with an excess of sodium sulfite fed continuously.

Softener

The softener is a "combined" sodium and hydrogen carbonaceous zeolite type in which salt and acid are both used for regenerating the same unit. The effluent is, in effect, similar to that obtained from mixing the effluents of separate sodium and hydrogen zeolites.

A considerable saving of space and simplicity of operation is inherent in this combination, since only two separate units are required as compared to four separate units if "mixed" sodium and hydrogen effluents are used.

By adjusting the quantities of acid and salt used in regeneration, the softener can be operated in the alkaline, neutral or acid range.

Each unit has a rated capacity of 180,000 gal. (1,500,000 lb.) of Lake Michigan water per regeneration, at a normal flow rate of 250 gpm. and a peak rate of 500 gpm. The hardness varies from a 6 ppm. maximum to a 1 ppm. minimum, with a mean value of approximately 2 ppm. All surfaces in contact with the acid water are either hard rubber or rubber-lined steel.

To provide an uninterrupted flow of softened water, one unit carries double capacity while the other is being regenerated. The acid required for regeneration is obtained in carload quantities as commercial 66° Bé sulfuric, and stored in a steel tank outside the plant.

Pumping the acid into a lead-lined weighing tank provides the means of measuring the 232 lb. needed for each regeneration. From the weighing tank, the acid flows into a large lead-lined tank for dilution to 1.25 per cent H_2SO_4. The 180 lb. of salt for each regeneration is obtained by volume measurement of a saturated solution.

In the regeneration procedure the dilute acid is first slowly flowed through the layer. Then the softener is partially drained and the salt solution is injected and diluted above the surface. After the salt treatment, the unit is rinsed with raw city water until the acidity of the effluent is reduced to the specified value.

Under present conditions, the acidity is 20 ppm. and the hardness about 6 ppm., as equivalent $CaCO_3$.

The time required for one complete regeneration is 1¼ hr. At continuous

full-load operation, each unit is regenerated once every 6½ hr.

Degasification

The softener operation, in the acid range of pH 3.7 to 4.0, allows a 99 per cent complete conversion of the carbonate ion to free carbon dioxide (6). Degasification under this condition makes it possible to remove the carbon dioxide and dissolved oxygen simultaneously.

Application of this principle, under conditions most favorable to plant economy and simplicity of operation, requires the design of a degasifier which operates under a vacuum of 27 to 29" Hg and corresponding saturation temperature. It is a three-stage, spray-type apparatus, with 5°F. interstage heating.

The CO_2 is thus reduced to 2 or less ppm. and the O_2 to less than 0.02 ml. per liter.

A copper inner lining protects the outer steel shell from corrosion by the acid water. The surface of this lining has acquired a purple-colored hue indicating the presence of a protective thin oxide film.

The spray nozzles are made of high-silicon bronze and, although no observable wear is evident in 2 years of service, a small increase in maximum capacity has resulted, especially in the first stage. The pumps for interstage circulation are also made of high-silicon bronze and, up to the present time, there is no evidence of abnormal wear.

pH Control

The presence of 5 ppm. free mineral acid in the treated water gives a pH of 4.0 at the degasifier outlet.

To prevent corrosion of the subsequent lines and equipment, caustic soda is injected. The caustic feed is automatically controlled, in accordance with water flow requirements, by a dual combination water flowmeter and glass electrode pH recorder.

Phosphate Treatment

For feeding phosphate to the boiler, connections into the upper front drum were initially provided, but the feeding equipment was omitted, since it was desired to try feeding the phosphate along with the alkali used for pH adjustment at the degasifier outlet. By pH adjustment it was expected that heater deposits could be prevented. This method did not prove feasible, however, because sufficient lowering of pH to prevent calcium phosphate deposits allowed corrosion to occur. The pH range, in which phosphate deposits stopped and corrosion began, was not determined, due to other variables entering which did not bear directly on this problem.

At present the phosphate is fed intermittently with a pot-feeder connected across three stage-heaters, to obtain pressure differential.

Adjustment of the amount of monosodium and trisodium phosphates affords control of alkalinity and phosphate concentrations in the boiler water. Other concentrations are controlled by continuous blowdown.

Turbine-Blade Deposits

In spite of the low phenolphthalein alkalinity allowing only 0.25 ppm. solids in steam, deposits form on the turbine blades mostly as insoluble silica. An effort was made to counteract this deposit by maintaining in the boiler water a ratio of caustic to silica of at least 2 and a low phosphate concentration based on the theory (7) of keeping silica in the steam in the form

of sodium silicate, since it is water soluble and can be removed from the blading by washing with wet steam.

The theory apparently proved correct, but was not practical. Turbine-stage pressure readings indicated that the insoluble silica deposits were eliminated but the rate of deposition of soluble salts required too frequent washing to be economical.

Steam purity measurements during this trial indicated a 100 per cent increase in total solids, but a 50 per cent decrease in silica.

As previously mentioned, the quite recent theory advocated by Spillner, that boiler-water salts are soluble in steam and form by crystallization on the blades, has provided a new approach to the problem.

After reduction of solids in the steam to a minimum, by favorable water conditioning and mechanical scrubbing, any further progress must be in the direction of inhibiting crystallization on the blades.

Evidence that the use of sodium sulfite as an oxygen scavenger incidentally prevents turbine deposits has been recently discussed. Certain types of suspended matter may also be effective.

The practical importance of this problem will certainly spur increased effort toward its solution.

References

1. Fitze, M. E. Oxygen Analysis in the Boiler Room. Power, **72**: 136 (1930).
2. Straub, F. G. Embrittlement in Boilers. Engineering Expt. Station, Univ. of Ill. Bul. No. 216, Vol. 28, (Oct. 21, 1930).
3. Weiser, H. B. *The Hydrous Oxides and Hydroxides.* John Wiley & Sons, Inc., New York, pp. 86–88 (1935).
4. Edison Electric Institute translation of *Die Chemische Fabrik,* **22**: 405 (Nov. 2, 1940) "Highly Compressed Steam as a Solvent."
5. Straub, F. G. Solubility of Salts in Steam at High Pressure. Proc. Third Annual Water Conference, Engineers Society of Western Pennsylvania (1942), p. 31.
6. Amorosi, A. M. & McDermet, J. R. The Calculation of the Distribution of Carbon Dioxide Between Water and Steam. Proc. A.S.T.M., **39**: 1204 (1939).
7. Tray, S. E. & Imhoff, C. E. A New Theory of Turbine Blade Deposits. Preprint from Allis-Chalmers Power Review (Nov. 1942).

Fundamentals of Utility Extension Rules

By E. F. McNaughton

THE Railroad Commission of California has opened an investigation into water service rules and regulations. Public hearings were held at San Francisco, Monday, December 6th and at Los Angeles, Thursday, December 9th both before Commissioner Carl C. Baker. The tentative proposal contemplates eighteen standard rules for basic application, subject, of course, to amplification or modification to meet particular requirements of individual companies.

One of the outstanding rules, as to importance, relates to the basis of making extensions to serve new territory.

This, of course, taps the fundamentals of the water works business while the service area is growing. Extension rules should be framed so as to encourage desirable new business, to add to and to build up the system, yet safeguard the main body of consumers by keeping out growth that is unprofitable and that otherwise would be a burden to the main system.

A review of the extension rules of the larger gas, electric, telephone and water companies subject to commission jurisdiction has recently been made. This summary naturally divides into two categories: (1) the ordinary extension sought by one or a group of potential customers; and (2) the real estate subdivision extension to serve newly developed tracts.

A paper presented on October 29, 1943, at the California Section Meeting, Los Angeles, Calif., by E. F. McNaughton, Director, Public Utilities Department, California Railroad Commission, San Francisco, Calif.

Ordinary Extensions

Ordinary extension rules contemplate an extension of a reasonable maximum amount at the expense of the utility, and that the amounts in excess thereof be advanced by the prospective customers. After this fundamental is observed, however, details of carrying out the rules vary greatly.

First, what is the amount of free footage to which a new customer should reasonably be entitled? Generally speaking, a free main extension of 100 ft. to 150 ft. per customer is provided in existing rules of California water companies.

Second, is the amount advanced over the free footage to be refunded or not? Generally, where the advance is an approximation of the cost of making the extension, existing rules provide for refunds. Where the advance is token or nominal, however, it is regarded as a donation in aid of construction and is not refundable.

Hence, we find here one of the essential determinations. Should the advance deposit be nominal, merely sufficient to provide a deterrent to ca-

pricious demands, or should it approach the actual cost or perhaps even further than the construction cost and contain an operating subsidy? Or should a higher rate be prescribed for the area?

Generally speaking, rules for water companies provide for advance deposits subject to refund for line lengths installed over the free footage of 100 to 150 ft. per customer. Refunds of most of the water utilities are based on a refund of the cost of 100 or 150 ft. of main for each additional consumer. Some companies, however, provide for dollar refunds per consumer; the dollar refunds range from $20 on up to $50. Most of the refund provisions terminate at the end of 10 yr., although in some cases a 5-yr. or 7-yr. period is used.

The electric and gas extension practices have been developed on a free length basis, measured in feet, for each type of equipment installed by the customer. The advance, generally speaking, is on an estimated cost per foot rather than on the actual cost of the particular extension, as in the case of water companies. The electric companies uniformly require an advance of 25¢ per foot (except in the case of the substandard type of extension). One large gas company requires an advance of 75¢ per foot. Studies of these costs are under way and a preliminary summary of the costs indicates that for all jobs, regardless of location, line classification, or year of installation, that the electric extensions have cost 30¢ per foot; the gas installations have cost 74¢ per foot. Further refinement of this study is now in progress.

The extension practice of telephone companies has been developed on the basis of nonrefundable extension charges, but at a very low initial cost. The initial deposit beyond the free length ranges from 1¢ to 2¢ per foot of extension.

Some of the rules of the city-operated services that have come to our attention are of interest. One city, for example, refunds water extension deposits on the basis of lump sum of $100 per ⅝-in. meter, ranging on up (depending on the size of the meter installed by the customer) to $600 for a 6-in. meter. This procedure, in effect, gives weight to the size of the new load brought on. Another city requires a deposit of 60¢ per front foot of property, which is nonrefundable. Still another city requires no advance at all.

Real Estate Subdivisions

Another series of rules applies to the extensions to service real estate subdivisions. Generally speaking, with the exception of the California Bell Telephone Company, all classes of utilities require that the total cost of placing mains or lines within real estate subdivisions be advanced to the utility by the subdivider.

Refund provisions for real estate subdivisions are extremely varied under the presently filed rules. Independent telephone companies generally refund on a basis equivalent to one year's service charge for each telephone connected, the time limit for refunds being 5 yr. Electric companies refund on the basis of dollars for types of load for 10-yr. periods. Some gas companies refund on the basis of dollars for each type of connected load, while another major company refunds on the basis of the cost of 150 ft. for each new customer. Another company refunds on the basis of cost of 100 ft. of main, plus four times the estimated first year's billing over $40.

Quite a variety of refund provisions for subdivisions exists among water companies. Some refund on the basis of the cost of 150 ft. of main for each customer, while others refund on the basis of dollar amounts for each customer, and others on the basis of a percentage of gross revenue derived from the tract. Some have a rather unusual provision in that the whole deposit is refunded in one lump sum when the gross revenue in any one year is equal to 25 per cent of the deposit.

Impact of War

With the advent of war several water companies raised the question of service to housing projects and subdivisions located in defense areas. Under their rules, refunding on the basis of the cost of 150 ft. of main for each customer, the advance deposits would be immediately refunded. The Commission in these cases has authorized for the duration a special rule permitting refunds on the basis of 35 per cent of the annual gross revenue.

The impact of war through the priority system meant that many subdivisions started under peacetime conditions would lie dormant during the war, particularly in the higher priced residential areas. With the time limit for refunds running, however, it became apparent that injustice might be done to the subdividers of these tracts. After public hearings, the Commission issued an order in its docket for emergency rules and regulations for the national emergency, which has the effect of extending the time limit for such refunds by an amount equal to the duration of the war plus six months. This order applies to all privately-owned gas, electric, water and telephone utilities.

Summary

There are certain basic principles involved in establishing the extension rule for water utilities, which were considered by the Commission in the hearings:

1. What is the proper initial length of extension to be made at the expense of the utility? The proposal which the Commission staff has submitted calls for a main extension up to 150 ft. per service connection, except in subdivisions.

2. Should the amount of the deposit for extensions in excess of free length be a comparatively small token payment, or should it approximate the original cost of the extension, or should it also incorporate an added amount or a higher rate zone as a possible operating subsidy? The Commission staff recommendation is that the actual cost of the main (not to exceed 4 in.) be advanced after deducting the free footage.

3. Should the amount of the advance deposit be subject to refund? It is believed that it should be subject to refund.

4. If refundable, what is the fairest and most equitable basis of the refund? The basis proposed by the staff is at the rate of the cost of 150 ft. for each service connection.

Another problem that has been called to the attention of the Commission on several occasions is whether a co-ordinated program could be worked out between the utilities, including all classes, so that before a subdivision is laid out, provision will be made for all utility service to the subdivision. This, if carried to its ultimate conclusion, is quite a large order, and there are many obstacles in the way of its acceptance, but it would appear to offer sufficient advantage to make it worthy of study.

Discussion

J. S. Longwell *

I have read with a great deal of interest Mr. McNaughton's paper. The action of the California Railroad Commission is commendable in developing a program of standardizing procedure relative to the extension of water mains by private water companies.

Experience in the East Bay Municipal Utility District has led to the conclusion that credits for new services should be limited to an amount which will not encourage the subdivider to erect houses at certain predetermined locations and thereby obtain the complete system of mains without cost. At the same time, the credit for such new services should be high enough so that it will not work a hardship on the individual building his own home and requiring a main extension. A credit of 150 lin.ft. of pipe per service seems rather high, as 150 ft. of 4- or 6-in. cast-iron pipe will cost well above the value of an individual service, and will readily permit the installation of mains in a subdivision entirely at the expense of the water department. It would seem that a credit of a flat amount, say $100 per service, would be preferable and would eliminate, to a large extent, the troubles mentioned.

Initial Financing

Under wartime conditions, in critical defense areas where most of the housing is more or less of a temporary nature and usually in large projects, it is believed that the initial financing should be done entirely at the expense of the subdivider. The use of the housing after the war is uncertain and the water department, company or district should not be required to invest in mains which may be used only a few years.

As a general policy, it is believed that refunds to the subdividers should be made on the basis of water used rather than by a flat amount per service or the value of 150 ft. of pipe. It is the District's practice to refund 70 per cent of the amount of the water bills over a ten-year period, or until the full cost of the installation is refunded in case less than ten years is required. This gives greater refunds to larger users of water and encourages water sales. In the case of war housing projects, it provides for refund just as long as water is used, a desirable arrangement under the present situation.

Water main installations should in general be charged for at a rate high enough to prevent any undesirable installations and yet low enough to encourage subdivisional developments. The practice of charging on the basis of the cost of 4-in. pipe seems good practice. This District has found it desirable to establish fixed prices per linear foot of pipes, regardless of the size used but varying with the type of paving in which the main is to be installed, such as concrete, oil-macadam or dirt. These prices are based on the use of 4-in. cast-iron pipe, and hold except for pipe larger than 8 in. in diameter and expect for special conditions such as railroad crossings and similar items, all of which are included at actual estimated cost.

The subject of water main extension regulations is of interest and concern to all water works organizations, and it is to be hoped that some basis can be developed which will tend to standardize methods among the many departments, companies and districts.

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Effect of Storage Reservoir Detritus on Ground Water

By T. V. Ackerman and E. J. Lynde

THE purpose of this paper is to present actual data on the effect of decomposition of organic matter deposited in Devils Gate Reservoir on the ground-water supply in Monk Hill Basin.

Devils Gate Reservoir is located in the northwest section of the city of Pasadena, Calif., and was constructed primarily as a flood control project for the Arroyo Seco. The dam was completed in June 1920 with an original reservoir capacity of 4554 acre-ft., but subsequent storms have reduced this capacity (through deposits of alluvial and organic matter after the 1938 flood) to 2967 acre-ft. The elevation of the reservoir bottom at the dam is 40 ft. above the original elevation.

The drainage area above the dam is about 31 sq.mi. of which the Arroyo Seco is the principal tributary, having a drainage area of about 21 sq.mi. in the Sierra Madre Range, north of the city of Pasadena. This stream has an average yearly discharge of about 7500 acre-ft. It is typical of all mountain streams in southern California, and during flood stages carries a large amount of silt and debris. Normally, most flows up to 20 fps. are diverted about one-half mile above the mouth of Arroyo Seco Canyon for domestic use by the city of Pasadena. This means that only flood flows during the rainy season enter Devils Gate Reservoir as surface flow.

Monk Hill Basin is a nearly closed ground-water basin underlying the vicinity of Devils Gate Reservoir and the northwest section of the city of Pasadena. This basin covers an area of about 4000 acres and has an annual safe yield of 6060 acre-ft. The supply to this basin is from Arroyo Seco percolation and underflow, percolation from Devils Gate Reservoir, percolation from rainfall on the overlying valley floor and from a few minor sources. The city of Pasadena operates four wells in this basin. The city also has about one mile of water tunnels, known as the Devils Gate Tunnels, underlying areas in close proximity to the Devils Gate Reservoir. These tunnels will be described later in more detail.

To illustrate the effect of Devils Gate Reservoir detritus on the ground water of Monk Hill Basin, mineral and sanitary analyses of the following sources of supply are used as an index of changes in the quality of this ground water:

Arroyo Seco Surface Flow. Analyses of this supply, taken at the diversion works about one-half mile above

A paper presented on October 28, 1943, at the California Section Meeting, Los Angeles, Calif., by T. V. Ackerman, Asst. Purif. Supervisor and E. J. Lynde, Asst. Engr., Pasadena Water Dept., Pasadena, Calif.

the mouth of Arroyo Seco Canyon, show the quality of the flow which supplies Devils Gate Reservoir with its principal source of inflow and which supplies Monk Hill Basin through percolation and underflow.

Arroyo Well (No. C5a). This is a 26-in. well drilled to bedrock and was completed August 22, 1930. Total depth (including shaft) is 668 ft. below the normal ground surface. This well is located in Monk Hill Basin in the alluvial fill below the mouth of Arroyo Seco Canyon and receives its supply mainly from the Arroyo Seco percolation and underflow entering the upper part of Monk Hill Basin, upstream from the reservoir. Since this well is above the range of influence of Devils Gate Reservoir, analyses are used, along with analyses of Arroyo Seco surface flow, to show that no material change has taken place in the quality of either Arroyo Seco surface or underflow.

Devils Gate Tunnels. These consist of about one mile of tunnels through bedrock and alluvial fill and underlie an area in the vicinity of Devils Gate Reservoir. These tunnels were constructed in the early part of the century and were acquired by the Pasadena Water Department when the department was formed in 1912. Prior to the construction of Devils Gate Dam, the water department lined 3796 ft. of these tunnels with concrete, which completed the lining of all tunnels except such portions as were in solid rock. An approximate location of Devils Gate Tunnels is given as follows:

(1) About 1330 ft. of tunnels extending in a southeasterly direction from the east abutment of Devils Gate Dam. These tunnels reach a maximum distance of about 1000 ft. east and 400 ft. south of the east abutment and culminate in a tunnel portal about 350 ft. south of the intersection of La Canada-Verdugo Road and Atlanta Street. The total tunnel flow discharged from this portal when tunnels were in use was diverted to Sunset Reservoir in the Pasadena Basin. Tunnel cover ranges from about 35 ft. near the east abutment of Devils Gate Dam to about 120 ft. at the end of the easterly tunnel.

(2) About 630 ft. of tunnels, continuing in a northwesterly direction from tunnels noted in (1) from the east abutment of Devils Gate Dam to a point about 200 ft. above the face of the dam and then in a westerly direction, parallel with the face of the dam, to a point opposite the west abutment. Tunnel cover at the present time ranges from about 30 to 50 ft.

(3) About 1430 ft. of tunnel, continuing from the tunnels noted in (1) from the east abutment of Devils Gate Dam in a northerly direction, roughly parallel with the east bank of Devils Gate Reservoir, and ranging from about 50 to 120 ft. inside the high water line along the east bank. Tunnel cover ranges from about 35 to 80 ft.

(4) About 1420 ft. of tunnel continuing from the upper end of tunnel noted in (3) in an easterly direction from Devils Gate Reservoir to Figueroa Well. Tunnel cover ranges from about 75 to 160 ft.

Analyses of flow from Devils Gate Tunnels naturally show a greater change in quality than wells located at a greater distance from the reservoir, and this tunnel flow was the first water supply which had to be discontinued due to the effect of Devils Gate Reservoir detritus. Use of flow from Devils Gate Tunnels had to be discon-

tinued in August 1936 and constituted a major loss in gravity supply.

Figueroa Well (No. C6a). This is a 26-in. well drilled to bedrock and was completed December 5, 1929. It was drilled in a shaft located at the eastern end of the upper Devils Gate Tunnel system. Total depth (including shaft) is 701 ft. below the normal ground surface. This well is located in Monk Hill Basin about 1400 ft. east of the upper portion of Devils Gate Reservoir and about 2900 ft. south of Arroya Well. Figueroa Well is the only well to date which has had to be completely abandoned due to the effect of Devils Gate Reservoir detritus. The well was not used during the fiscal years of 1934–35, 1935–36, 1937–38, and 1938–39, and was abandoned in March 1940. Both the casing and the pump column were found to be in a corroded condition due to the high carbon dioxide content of the water. Since Figueroa Well is located at the upper eastern end of the Devils Gate Tunnel system, an attempt was made to shut off any tunnel flow which might reach the well during high water by placing a bulkhead in the tunnel. This was not successful, however, since Devils Gate water still seeped around the bulkhead and entered the well.

Casitas Well (No. C7). This is an 18-in. well drilled to bedrock and was completed June 22, 1909. Total depth (including shaft) is 566 ft. below the normal ground surface. This well is located about 1800 ft. east of the lower portion of Devils Gate Reservoir and about 1100 ft. south of Figueroa Well. Casitas Well seems to be the next well on the list to be abandoned due to the effect of Devils Gate Reservoir detritus and has been pumped only occasionally since November 1942 to augment the supply during periods of peak consumption. A recent analysis of Casitas Well (not shown on Figs. 3, 4 or 5) was made October 5, 1943,

TABLE 1

Elevations (U. S. G. S.)
Wells

Well Name and No.	Normal Ground Surface El.	Bottom El.	Water Surface			
			Maximum		Minimum	
			Date	El.	Date	El.
Arroyo (C5a)	1090	422	5-16-41	1024	9-22-33	895
Figueroa (C6a)	1132	431	6- 3-41	1020	12- 1-33	896
Casitas (C7)	1109	543	5-12-22	1018	11-15-33	894

Devils Gate Reservoir

Max. Storage El. = 1054.22

Reservoir El. Bottom at Dam: Original = 970; After 1938 Storm = 1010

Devils Gate Tunnels
(Floor El.)
Max. = 967.78 (at Shaft No. 10)
Min. = 959.05 (at Tunnel Portal)

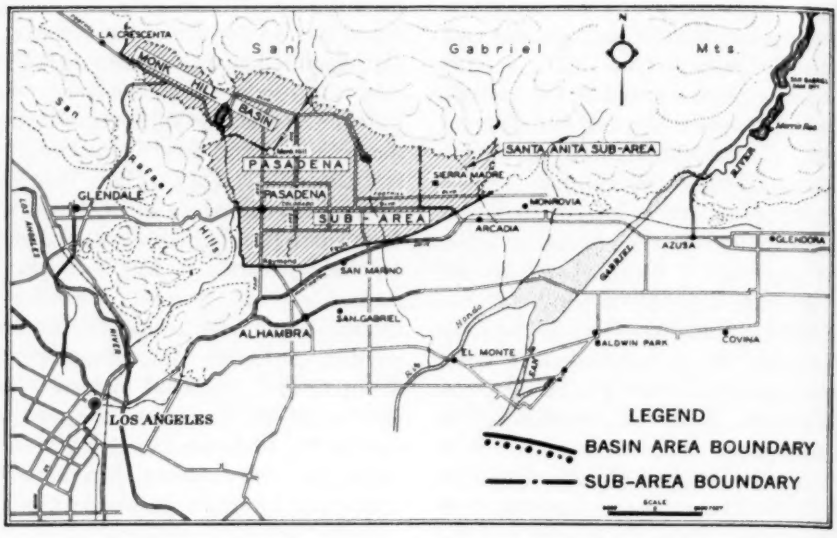


FIG. 1. Key to Raymond Basin Area

LEGEND
42 WELL OWNED BY ENTITY IN SUIT OR PREDECESSOR
118 WELL OWNED BY PARTY NOT IN SUIT
BASIN AREA BOUNDARY
SUB-AREA BOUNDARY

FIG. 2. Location of Wells Used Since 1913

TABLE 2

Production

Source of Supply	Average Yearly Production Acre-Ft. (1913–14 to 1942–43)				Capacity in gpm.		
	Prior to Completion of Devils Gate Dam		After Completion of Devils Gate Dam		Avg.	Max.	Min.
	No. of Years	Avg.	No. of Years	Avg.			
Devils Gate Tunnels	7	3206	16	1162	——	5506	Dry in 1929
Arroyo Well (C5a)	——	——	12	1304	1994	——	——
Figueroa Well (C6a)	——	——	7	559	1904	——	——
Casitas Well (C7)	7	287	19	286	1012	——	——

and showed a carbon dioxide content of 35 ppm. and a total hardness of 277 ppm., a new high for carbon dioxide and total hardness for this well.

Locations of all items mentioned so far in this text are shown on Figs. 1 and 2, with the exception of Devils Gate Tunnels, the approximate location of which has already been given in detail.

Elevations of wells, tunnels and water tables are shown in Table 1 and, in order to furnish data on the magnitude of supplies involved, the production of wells and tunnels is shown in Table 2.

To show at a glance the change in quality of Monk Hill Basin ground water, all available analyses since 1918 of carbon dioxide and total hardness for the five sources of supply used as an index have been plotted and are shown on Figs. 3 and 4. Also diagrams of mineral analyses for the five sources of supply are shown on Fig. 5. These analyses (Fig. 5) are simply the first available analysis providing sufficient data and the last analysis for each source of supply with the exception of Arroyo Seco surface flow. Analyses of Arroyo Seco surface flow cover a long period of time and the dates chosen were those that most closely compared with Devils Gate Tunnels. If analyses had been available on the same date for all sources of supply, these would have been used instead.

These diagrams need little explanation and show the rapid increase in carbon dioxide and total hardness in Devils Gate Tunnels, Figueroa Well and Casitas Well during the past eight years (1936 to 1943, inclusive). The additional carbon dioxide is a product of the decomposition of organic matter deposited in Devils Gate Reservoir. This carbon dioxide in turn reacts on alluvial deposits and increases the alkalinity and total hardness of the water. Carbon dioxide is not normally present at the surface of water stored in Devils Gate Reservoir, but begins to show up at the bottom of the reser-

voir and increases as percolating water passes through the reservoir detritus. This is evidenced by an analysis made on April 29, 1942, which showed a carbon dioxide content of 0 ppm. at the surface, 13 ppm. at the bottom (17 ft. below the surface), and 140 ppm. in Devils Gate Tunnels.

In July 1934 and October 1935, fires occurred in the Arroyo Seco drainage area and the resultant organic matter deposited in Devils Gate Reservoir by subsequent storms probably accounts in part for the rapid change in the quality of the water following the period of these fires. The total hardness of 287 ppm. for Arroyo Seco surface flow in 1935 is probably a result of increased carbon dioxide in the drainage area caused by increased decomposition following these fires.

The variations in analyses of flow from Devils Gate Tunnels beginning in 1936 have not been definitely accounted for, but are probably a result of dilution with water reaching the tunnels from Arroyo Seco underflow in vary-

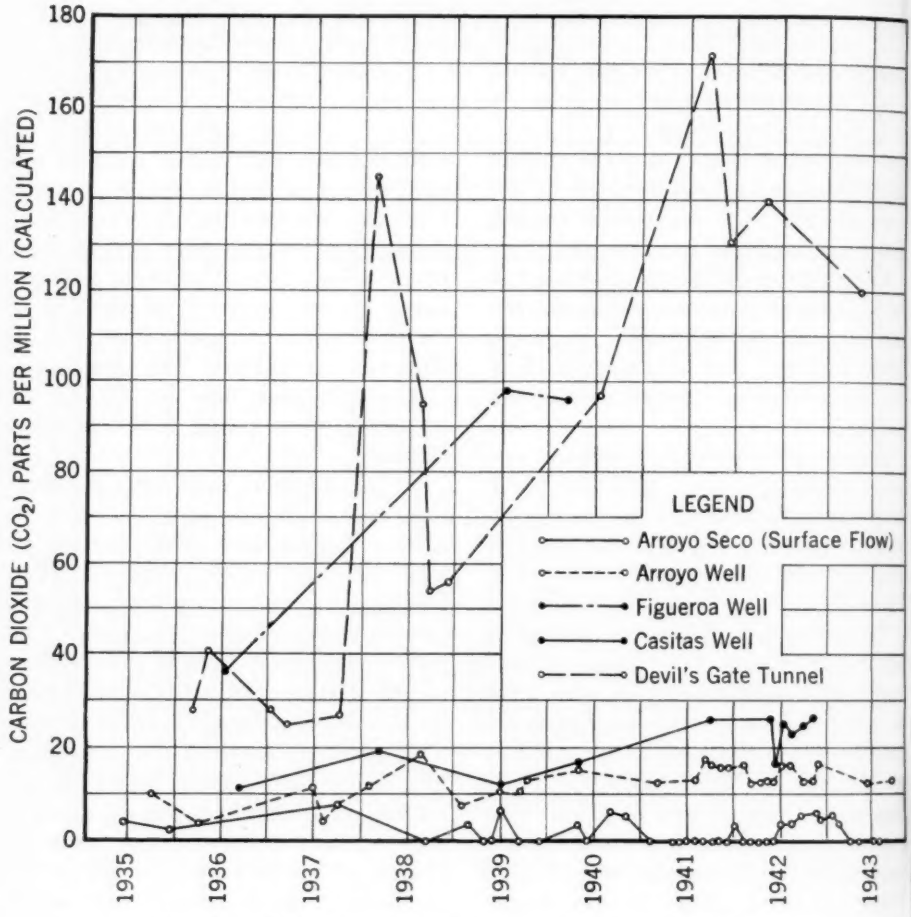


FIG. 3. Effect of Devil's Gate Reservoir on Ground Water

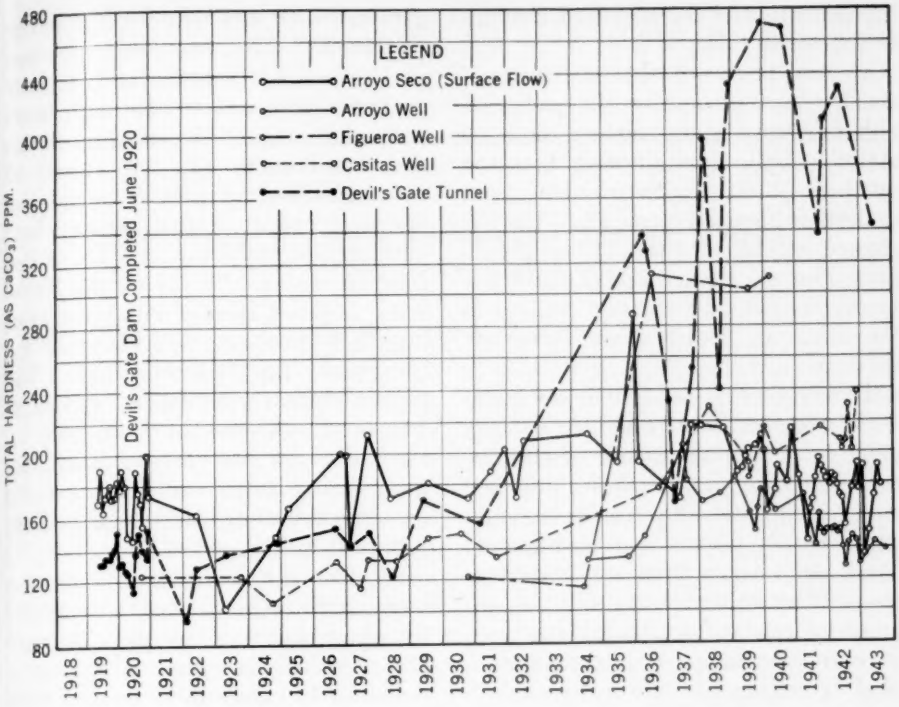
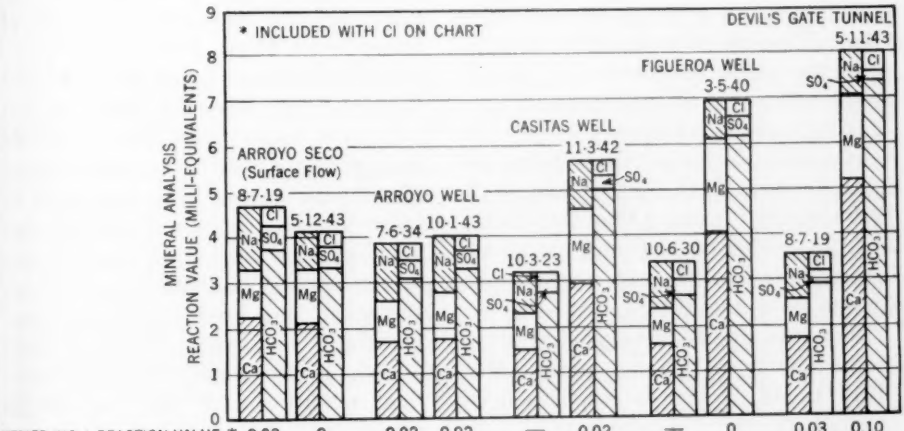


FIG. 4. 13-Yr. Chart of Effect of Devil's Gate Reservoir on Ground Water



NITRATE (NO_3) REACTION VALUE	* 0.03	0	0.02	0.02	—	0.02	—	0	0.03	0.10
NITRATE (NO_3) PPM.	1.8	0	1.1	1.3	—	1.1	—	0	1.8	6.0
CARBONATE (CO_3) PPM.	0	0	0	0	0	0	0	0	—	0
EVAPORATED SOLIDS PPM.	268	258	226	233	221	299	219	370	207	459
pH	—	8.2	—	7.4	—	7.2	—	6.8	—	6.8
$CaCO_3$ SAT. INDEX (AT 25° C)	—	+0.51	—	−0.35	—	−0.16	—	−0.40	—	−0.24

FIG. 5. Mineral Analysis Ground Water, Pasadena Water Dept.

ing amounts and the effects of changes in the water table.

It will be noted that no material changes have occurred in the quality of either Arroyo Seco surface flow or Arroyo Well, thus showing that the qualities of Arroyo Seco surface and underflow have not changed. Thus the change in quality of water from Devils Gate Tunnels, Figueroa Well and Casitas Well must be attributed entirely to the effect of Devils Gate Reservoir detritus.

It will also be noted that no material change has occurred in the sodium, chloride or sulfate content of the five sources of supply. Thus the principal changes to date occur in the supplies from Devils Gate Tunnels, Figueroa Well and Casitas Well and constitute an increase in carbon dioxide; an increase of calcium bicarbonate and magnesium bicarbonate (more than doubled in each case); and a corresponding increase in evaporated solids. A decrease in pH and a decrease in the value of the saturation index would undoubtedly show if data were available. Although not shown on Fig. 5, an increase also occurred in silica and in the oxides of iron and aluminum. This increase is, of course, greatest in Devils Gate Tunnels where silica increased from 32.0 ppm. (August 7, 1919) to 53.7 ppm. (May 11, 1943) and the oxides of iron and aluminum increased from 0.80 ppm. to 8.9 ppm. for the same dates.

Since the above mentioned changes in the quality of ground water are a direct result of the decomposition of organic matter deposited in Devils Gate Reservoir, it is reasonable to believe that organic tastes and odors would also occur and that an environment suitable to the growth of organisms, such as Crenothrix, would be established. This was true in the case of Devils Gate Tunnels, and, as early as 1922, there was trouble with tastes and odors. In 1927, the tunnel section listed under (2) was closed off by a bulkhead to prevent tastes and odors occurring in that section from entering the main tunnel. From that time on and as the pH of the tunnel water lowered, trouble with growths of organisms in the tunnels increased and the gravity line from the tunnels had to be treated with copper sulfate to prevent these growths from entering the line. At the present time, the tunnels are infested with heavy growths of Crenothrix and Beggiatoa and the tunnel flow is high in color.

Devils Gate Tunnels also show a large increase in nitrates accompanied by a large increase in organic nitrogen and ammonia nitrogen. The water is definitely bad and cannot be used without expensive treatment. The loss of this gravity supply is costly and can be shown as the pumping costs of pumping an equivalent amount of water from Monk Hill Basin.

To summarize, it can be stated that Devils Gate Reservoir detritus has created a marked deterioration in the quality of the nearby ground water of Monk Hill Basin. The supply of almost a mile of tunnels, which once supplied the city of Pasadena with more than 50 per cent of its total consumption, has been lost and a comparatively new well has been abandoned. Only time will tell whether this condition will improve or get worse and either eventually cause other wells to be abandoned or make necessary the building of a treatment plant for the water supply from Monk Hill Basin.

The Ohio Plan for Financing Sewage Works Improvements

By Wendell R. LaDue

SINCE the turn of the century Akron, Ohio, has been an important industrial city and, as such, had a phenomenal growth during and immediately after World War I (between 1910 to 1920 the population skyrocketed from 69,000 to 208,000); suffered in the lean years of the early twenties; rose to a peak of industrial effort culminating with the panic year 1929; cared for helpless thousands of workers out of jobs through the depression years of the thirties and now, in the midst of a second world war, finds itself a marvel of war-production effort.

Since Akron has been an industrial city, so it will undoubtedly remain and receive its share of the heritage of World War II. The strange legacies of rapid growth have produced many unusual problems in municipal planning, financing and engineering. The most prominent efforts have been those pertaining to water supply and sewage treatment and disposal.

Water Supply

Akron's water supply began in 1880 with developments by private capital. By 1910, it became quite evident that private capital either would not or could not take the risk of the larger capital investment necessary to abandon the old supply and to develop a new source more satisfactory in quality and more adequate in quantity to meet the needs of the growing city.

Therefore, in April, 1912, with public demand and acclaim, the city of Akron acquired the privately-owned water utility. Within three years subsequent to this acquisition (August, 1915), the present source of supply was selected and treatment and pumping facilities were built and placed in operation. Then followed a tremendous expansion of the distribution system made necessary by the phenomenal growth of the city during the following 15-yr. period. With numerous plant expansions, capital investment in the water utility continued to pyramid from the original purchase price of $920,000 to approximately $18,000,000 by 1940 as follows:

Years	*Capital Investments*	*Total Investments*
1912–15	$4,580,000	$ 4,580,000
1916–20	5,425,000	10,005,000
1921–25	2,200,000	12,205,000
1926–30	3,478,000	15,683,000
1931–35	606,000	16,289,000
1936–40	1,139,000	17,428,000
1941–43	700,000	18,128,000

A contribution by Wendell R. LaDue, Supt. & Chief Engr., Bur. of Water & Sewerage, Akron, Ohio.

The acquisition of the original plant and enlargement through subsequent construction were all financed by the sale of general city bonds further secured by water revenues. (Jour. A.W.W.A., **29**: 1580 (1937).)

Water Rates

At the time of acquisition in 1912, water was selling for a dollar per 1,000 cu.ft., with a minimum charge of $1.50 per quarter. In order to provide for the numerous improvements, the price of water was established at $1.20 per 1,000 cu.ft., with minimum domestic rate of $3.00 quarterly (effective April 1, 1916) followed in January 1, 1921, by a further increase to $1.60 per 1,000 cu.ft. with a minimum charge for domestic usage of $3.60 per quarter. This latter rate remained in effect until January 1, 1933, when, to combat the reaction following rate reductions by both private gas and electric utilities, the city administration reduced the minimum domestic water bill from $3.60 to $3.00 per quarter. This rate remained in effect until 1934 when, crowning a five-year effort, the discount system for payment of water bills came into being. The rate per 1,000 cu.ft. remained at $1.60, but the minimum bill for domestic consumers was set at $3.60 gross and $3.20 net per quarter. Continued reduction in debt service permitted the water rate to be reduced in 1941 from $1.60 to $1.50 per 1,000 cu.ft. with a reduction in the minimum bill to $3.40 gross and $3.00 net per quarter.

Operating and maintenance costs, as well as debt service, have naturally fluctuated with changing conditions. Income from the established rates, with the exception of two periods (1921–1924 and 1932–1935) has been adequate to meet operation costs and debt service charges. Since 1940 the income has increased steadily with increased production until, at the present time, the revenue from the sale of water is approximately $1,500,000 per year. Debt service charges have steadily declined from the peak of over $1,000,000 for the year 1937, when approximately 70–75¢ out of each dollar collected was required to meet debt service. Expenditures for operation and maintenance of the water utility for the decade of the thirties varied from $300,000 to $400,000 annually. Due to increased costs of both labor and material and to increased out-put, expenditures have risen to about $450,000 for 1943. The future picture forecasts a steady income of about the same amounts as in 1943, a fairly even operating cost and a declining debt service load, as shown in the following tabulation:

Year	*Income From Sales*	*Debt Service**	*Operating & Maintenance Costs*
1915	$ 275,000	$ 187,000	$100,000
1920	819,000	602,000	423,000
1925	1,093,500	824,000	347,000
1930	1,315,400	1,053,000	410,000
1935	1,196,000	877,000	280,000
1937	1,274,000	1,080,000	328,000
1940	1,350,000	1,013,000	362,000
1943	1,519,000	807,000	454,000

* Debt service for the original purchase was carried by general city funds.

Sewage Disposal

The history of sewage treatment in Akron has been turbulent from the beginning. Due to excessive stream pollution, the present plant was built after mandatory orders had been received from the Ohio State Department of Health. Bonds were issued under authority of an Ohio law which, under such orders, permits procedure, by ordinance of a city council without approval of the electorate, to build sew-

age treatment plants to abate a nuisance. Incidentally, the electorate on two previous occasions had defeated bond issues to authorize the sale of bonds for this purpose. As a consequence of this procedure, all debt service charges to meet the bond requirements had to be met out of the city's operating tax revenues. Construction was undertaken during the years 1927 and 1928, and the plant was placed in operation on December 11, 1928.

The plant was originally designed to handle an average flow of 33 mgd.; a maximum rate of 93 mgd. and a dry-solids load of 25 tons daily. The plans anticipated an expansion of the disposal plant around 1935. The capacity of the plant was reached prior to 1935, insofar as the solids load was concerned, and the average daily flow was reached at approximately the time anticipated in the design.

The depression of the early thirties made it very difficult for the city to provide funds from tax revenues for operation and maintenance, much less for plant expansion. The reduction in valuations on the tax duplicate for the city of Akron sent the percentage of indebtedness incurred over the maximum permitted by statute, making it impossible to sell bonds for plant additions. During the period of WPA and PWA existence, the Ohio statutes governing the sale of bonds were amended to permit the issuance of bonds exceeding the statutory limitation in: (1) cases where work relief resulted and (2) where the federal government participated in the cost. Under this program, two digester tanks were constructed with the federal government participating in the cost.

In order to maintain sufficient plant capacity, lagooning of sludge has been necessary since the early thirties. The large industries of Akron, especially rubber reclaiming plants, were requested to reduce the solids content of the wastes discharged. Full co-operation was given in most every instance with gratifying results in reduction of the solids load. With the advent of war industries a decided change in the solids problem has occurred, both in the character of the solid material encountered and in its quantity, which in spite of all efforts, has steadily increased to an excess of 85 tons per day. The changes resulting from the development and use of synthetic rubber to replace natural rubber and the increased activities in reclaiming processes create important problems.

Sewer Rental

Since 1923, Ohio statutes have provided for the application of so-called "sewer rental" to provide funds for the operation, maintenance, and expansion of sewerage systems and sewage treatment plants.

It has indeed proven most unfortunate that Akron did not avail itself of this power at the time of the construction of the plant. It appears to have been considered still to be in the experimental stage at that time. In 1935 efforts were made to place a sewer rental law into effect. Industry was contacted and agreed to the levying of a tax in an amount sufficient to provide for the operation, maintenance and expansion of the sewage treatment plant. The city administration then in office, however, in addition to requesting amounts sufficient to provide for the above functions, desired to obtain additional revenues sufficient for the maintenance and extension of main trunk sewers, for the retirement of bonds previously issued for existing main trunk sewers and for future sani-

tary sewer construction. Inasmuch as there was no meeting of minds, the legislation died before reaching the council for consideration. On several occasions since 1935, sewer rental bills have been presented to the council but were either rejected or did not reach a vote. Minority pressure groups have been exceedingly active in preventing the passage of a sewer rental law; one of the most active groups being an association of home owners.

The increasing revenue from the sale of water has been quite apparent. A declining water debt service load likewise cannot be denied. It is not strange, therefore, that many schemes should be devised to divert funds from water works surpluses for the rehabilitation of the sewage treatment plant and to assuage the acute sewage treatment problem. Most of these schemes have been based upon a more or less illogical, but nevertheless bothersome, reduction of water rates. Just two will be mentioned:

One suggested plan affected a deduction of 75¢ from each minimum water bill, all rates other than those having a direct bearing on the minimum bill to remain unchanged. This 75¢ was then to be assessed against the consumer as a sewer rental charge. The other scheme was to effect an arbitrary annual reduction in water revenues amounting to $300,000 to be offset by a levy of the same amount against properties in the form of sewer rentals. Reductions of this nature meant that the water utility would be arbitrarily forced to operate "in the red" for several years until reduced debt charges in future years evened the score. Proponents of both plans contended that the total charge for both water and sewer rentals would not exceed the original water bill.

State Statutes Governing Use of Water Works Funds

For many years the Akron Bureau of Water had operated under a state statute or code which read in part:

Sec. 3956. *Duties of director of public service.* The director of public service shall manage, conduct and control the water works, furnish supplies of water, collect water rents and appoint necessary officers and agents.

Sec. 3957. *By-laws and regulations.* Such director may make such by-laws and regulations as he deems necessary for the safe, economical and efficient management and protection of the water works. Such by-laws and regulations shall have the same validity as ordinances when not repugnant thereto or to the constitution or laws of the state.

Sec. 3958. *Assessment and collection of water rents.* For the purpose of paying the expenses of conducting and managing the water works, such director may assess and collect from time to time a water rent of sufficient amount in such manner as he deems most equitable upon all tenements and premises supplied with water. When more than one tenant or water taker is supplied with one hydrant or off the same pipe, and when the assessments therefor are not paid when due, the director shall look directly to the owner of the property for so much of the water rent thereof as remains unpaid, which shall be collected in the same manner as other city taxes.

Sec. 3959. *Disposition of surplus; how taxes applied.* After paying the expenses of conducting and managing the water works any surplus therefrom may be applied to the repairs, enlargement or extension of the works or of the reservoirs, the payment of the interest of any loan made for their construction or for the creation of a sinking fund for the liquidation of the debt. The amount authorized to be levied and assessed for water works purposes shall be applied by the council to the creation of the sinking fund for the payment of the indebtedness incurred for the construction and extension of water works and for no other purpose whatever.

Three provisions of this code are im-

portant: (1) The prerogative of the Director of Public Service to fix water rates has been zealously guarded. (2) Funds, designated as water revenues have been carefully segregated and deposited for the use of the water works *only*. (3) A definition of a real surplus and its use has remained somewhat obscure.

The requirement of the statute making mandatory the segregation of water works funds has resulted in other branches of municipal service casting longing eyes at the balances carried, and has resulted in schemes, both legal and illegal, to gain access to these funds. It has resulted in the refusal of self-supporting city and quasi-public functions to pay their legitimate water bills. It has caused agitation for construction, from these funds, of projects not a part of the water works system but obviously for "rental" to other departments. This resulted, during the depression years, in the passage of an act of the Ohio Legislature, permitting the diversion of 3 per cent of the *gross revenue* of the water works to poor relief with open disregard for the condition of the department as to "red" or "black." The association of water works funds with the feeding and housing of the poor is definitely hard to correlate. Even with the advent of better times, the desire for diversion has persisted.

In many states, the use of water works funds for municipal operations is openly practiced. Water works, in the main, being well operated, are looked upon as opulent and hence are placed continually on guard. As a means of providing a more positive check upon the misuse of water works funds; of reducing the desire to divert funds for sundry purposes; and, more particularly, of preventing unnecessary, and sometimes devastating, reductions in water rates; enactment was secured of the following act of the Ohio Legislature amending and clarifying Sec. 3959 of the General Code to read:

Sec. 3959. After paying the expenses of conducting and managing the water works, any surplus therefrom may be applied to the repairs, enlargement or extension of the works or of the reservoirs, the payment of the interest of any loan made for their construction or for the creation of a sinking fund for the liquidation of the debt. Provided, however, that in those cities where water works and sewerage systems are conducted as a single unit under one operating management a sum not to exceed ten per centum of the gross revenue of the water works for the preceding year may be taken from any surplus remaining after all of the preceding purposes have been cared for and may be used for the payment of the cost of maintenance, operation and repair of the sewerage system and sewage pumping, treatment and disposal works and for the enlargement or replacement of the same, provided, however, that each year a sum equal to five per centum of the gross revenue of the preceding year be first retained from said surplus as a reserve for water works purposes.

The amount authorized to be levied and assessed for water works purposes shall be applied by the council to the creation of the sinking fund for the payment of the indebtedness incurred for the construction and extension of water works and for no other purpose whatever.

This section was finally approved by the Legislature on May 26, 1943, after several public hearings at which all requests for clarification were satisfied. The governor signed the bill on June 8, 1943, with the effective date 90 days thereafter. This act was fostered by officials of the city of Akron and local state legislators and most of the support for its passage came from this same source.

It is to be noted that the bill provides several pertinent features:

First: The new law goes further

than the original statute by defining "surplus" as that portion of water revenue *remaining after* paying the expenses of conducting and managing the water works; paying for the repairs, enlargement or extension of the works or of the reservoirs; the payment of the interest of any loan for their construction; or for the creation of a sinking fund for the liquidation of the debt.

Second: A water works reserve is provided for in advance of any diversion of funds for sewerage purposes. This amounts to 5 per cent of the gross revenue and has first claim upon the water works surplus as defined. This 5 per cent reserve is an annual deduction and is cumulative. The water reserve from previous years is not used in the computation of any current year's surplus. This water reserve may be expended at the discretion of the service director for water works repairs, replacements, new installations or extensions—in lieu of bond fund expenditures—or to provide carrying charges for bond fund expenditures.

Third: It provides that 10 per cent of the *gross* revenue of the water works may be taken from this *surplus* to provide *only* for the payment of the cost of maintenance, operation and repair of the sewerage system and sewage pumping, treatment and disposal works and for the enlargement or replacement of the same.

Fourth: The amended act further provides that, *before* a diversion of funds can be made for sewerage purposes, both the water works and sewerage systems must be conducted as a *single unit, under one operating management.* This does not mean under the management of the director of public service, but rather sets up a *combined* operation under the management of a division head, responsible to the director of public service. The sponsor of this amendment had in mind making absolutely certain that the proper operation of the water works system would be amply provided for *prior* to permitting any diversion of water works funds. This safeguard has been incorporated in the act by the following sentence: "Ten per centum of the gross revenue of the water works for the preceding year may be taken from any surplus remaining *after all of the preceding purposes have been cared for.*" "Preceding purposes" refers back to the first portion of the act.

The "single unit" provision of the act permits maximum flexibility in the control of funds by the person in charge of combined operations of the water and sewerage systems and insures the proper usage of funds thereby (indirectly, but effectively) governing and controlling the amount of funds available for surplus.

An immediate benefit of the act has resulted. The legislature, in renewing the act permitting 3 per cent diversion for poor relief if desired by a council, has included a provision that the total diversion of water works funds by legislative act for all purposes shall not exceed 10 per cent of the gross revenue of a current year. Inasmuch as diversion for poor relief and for sewerage purposes are the only ones possible under existing laws, the legislature has co-operated to the extent of limiting all present diversion of water works funds to 10 per cent of the gross water works revenue. In those cities requiring and desiring 3 per cent for poor relief, only 7 per cent can be diverted for sewerage purposes.

Attention is further directed to the provision that, if the surplus, as above defined, provides an amount in excess

of 15 per cent (5 per cent for a reserve water works fund, 10 per cent for diversion to sewerage purposes) of the gross revenue, then the amount in excess of the 15 per cent remains a part of the water works funds. Such excess can be used for any well-advised rate reduction plan which would in no way restrict the efficiency of plant operations. These provisions will cause ill-advised proposals for rate changes to receive very careful scrutiny before being presented. Any change tending to reduce or remove the *surplus* will eradicate the benefits derived from use of that surplus.

A practical financial handling of a year's revenue under this act would be:

Annual Gross Water Revenue			$1,500,000
Annual Water Works Operation	450,000		
Annual Water Works Extension	100,000		
Annual Debt Service	700,000		
		Total	1,250,000
		Surplus	250,000
5 per cent Water Works Reserve	75,000		
10 per cent Diversion to Sewage Operation	150,000		225,000
Balance of surplus remaining in water works funds			$ 25,000

With the management of both the water works and sewerage divisions of Akron under one operating head, it is therefore believed possible under Ohio laws to divert up to $150,000 annually toward the functions of sewage works. It is probable that this amount of money, annually diverted and further secured by a dormant sewer rental law, would be sufficient under the present money market to service the debt incurred for a 2½ to 3 million dollar sewage treatment plant improvement program. This assumption is based on the issuance of 25-year serial bonds under the Ohio Uniform Bond Act which provides for equal annual retirements of bonds, together with interest payments. Issuance of revenue bonds by act of the council would also receive consideration. The additional security of a sewer rental law enacted by the council, but allowed to remain dormant on the books, but not operative, appears desirable to make the bonds attractive and saleable.

There is admittedly a trend throughout the United States toward the consolidation of water works and sewage treatment plants under one management. This presents many and varied new problems, all of which are by no means undesirable, however shocking they may appear at first blush. The main thing is that it is *new* and consequently requires *new* thinking.

It is believed that the principles set forth in this new Ohio act are sound and that any solvent water works and sewage treatment plant operated together can be benefited thereby in the development of its postwar operations and improvements. It is admittedly a violation of and an infringement upon the old principle that water works funds are inviolate. The diversion of water funds has been a municipal practice to which most water works men are allergic. However, under the old plan in Ohio, many ways were found to circumvent the law. It is believed that the new law has decided advantages and safeguards. Its further possibilities for assisting in solving the financial problems of postwar planning are submitted for careful consideration —and the time is *now*.

WILLING WATER SAYS

IT'S WARTIME STOP WATER WASTE

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Watering Lawns

EVERYBODY talks about the weather but nobody does anything about it, said Mark Twain many years ago. Little did Mark realize that in this day and age every home owner would have a lawn sprinkler for making rain whenever it was wanted.

The weather of the past decade has been so abnormally warm and dry that watering the lawn has become a regular part of the home routine. According to Weather Bureau officials, such warm, dry cycles are just a phase of normal climate. Some time, they say, the trend will be reversed to cooler, wetter weather. Even then lawn sprinkling will be important, but not quite such an ever-present problem as now.

The brilliant green lawns of the British Isles owe their beauty, not to any closely guarded secrets, but mainly to ideal moisture conditions. Gentle rains fall so frequently and atmospheric conditions are so favorable that there is no critical drying.

In the United States most sections east of the Rockies have an annual rainfall almost fifty per cent greater than that of England, yet the watering problem is more difficult. About the same amount of moisture falls each month throughout the year. Surprising as it may seem, June, July and August even have a slight edge over the other months. Unfortunately, evaporation during the summer is highest and many of the rains come as heavy, dashing storms. They do the grass little good because much of the water runs off the surface before it can be absorbed. There may be many such heavy rains during the summer with severe drouths in between. To offset this fluctuation and provide a more even moisture supply, a careful watering program is needed.

How Necessary Is Watering?

It is seldom necessary to water mature grass just for the sake of keeping it alive, but a carefully watered lawn does hold its spring color throughout the summer. On loam and clay soils a good turf can withstand severe and protracted drouth. It may turn quite brown, but unless cut too short it will be revived by the slow, drizzling rains of fall. This is not true of sandy soils. They dry so completely that even weeds may be killed in dry weather.

Some contend that grass needs a rest in summer and should not be forced by watering. For a direct contradiction of this theory one has only to look at golf course putting greens which are forced all through the summer and present a beautiful appearance year after year. If grass is fed regularly there is no reason for giving it a vacation just when a green lawn is most enjoyed.

Factors Affecting Water Needs

The amount and frequency of watering should be determined by the type of soil, height of cut, exposure of the lawn, temperature and rainfall.

Some soils have a greater moisture retaining capacity than others. If there is an abundance of organic matter this acts as a sponge to retain moisture and release it to the grass as needed. Because of their finer particles, loam and clay soils hold more water than sandy and gravelly ones.

Evaporation is reduced by cutting the grass 1½ to 2 inches high, because the longer growth shades the ground. High cutting promotes deeper rooting so grass can reach to a greater depth for moisture.

Steep slopes receive less benefit from rainfall and watering because there is more surface runoff. Those facing toward the south are subject to greater loss of moisture by evaporation.

When to Water

The amount and type of natural rainfall are the main factors affecting the timing of the watering program. A slow, soaking rain of ½ inch will do more good than a driving downpour of several times that amount. When rains have been missing for a week or two, it is time to examine the soil to see if it is getting too dry. Sometimes this condition develops much earlier in the spring than is realized. A bright sun and brisk wind can evaporate a lot of soil moisture within a few days, even in April. Therefore, the important thing is to start watering early enough in the season. Do not wait for the grass to show signs of withering. Once the soil gets too dry it is difficult to bring the moisture up to optimum again, especially if it is a heavy clay which bakes hard and cracks open.

A good lawn watering program cannot be scheduled by the calendar. The need for water is best determined by occasional examination of the soil. A good plan is to cut a small plug 2 or 3 inches deep with a knife or trowel. If the upper inch or so reveals any sign of dryness it is time to water. It is easy to replace moisture to that depth but if the soil is dry much deeper the task is more than proportionately greater.

Selecting the Sprinkler

Manufacturers of irrigation equipment have long since outmoded the old method of "sprinkling" a lawn by sitting on the step and flicking a stream of water over the lawn with a hose and nozzle. There was something fascinating about the job but it didn't help the lawn much.

Many excellent grass sprinklers have been developed during the past few years. The better types rotate or oscillate to deliver water in a manner resembling rain. A fine mist is not desirable because it is easily blown by the wind. On the other hand, a coarse stream is harmful because it washes the soil and puts the water on too fast. A sprinkler that provides the effect of a slow, easy rain is best because it allows the water to soak in as it falls and not flood the ground or run off the slopes.

In selecting sprinkling equipment the home owner should consider the size of his lawn and try to get a sprinkler which will water an area large enough so it won't have to be moved frequently. Some types cover a circular pattern, others a rectangular one. It is important to get a sprinkler that will operate satisfactorily on the pressure and volume available at the time of day when watering is done. The local water company should be able to give a close estimate as to the pressure available.

A convenient method of lawn irrigation is provided in the automatic underground sprinkler systems. These

save time and labor and will do the job nicely if properly designed and installed by capable engineers.

Sometimes these systems are misused. It is so easy to turn on the water and leave it on, that there is a tendency to over-water. Some installations are automatically turned on and off by a clock. Favorable results presuppose that the moisture need is the same over any given interval. That presumption is usually wrong and too much water is applied. This may not do much harm in a light sandy soil but it will be injurious on heavier soil. Over-watering drowns grass roots.

Quantity of Water

As the soil dries out it should be necessary to replace only as much water as was lost during the interval by evaporation from it and transpiration from grass leaves. From an average loam soil this loss on a warm summer day would be about 50 gallons per 100 square feet. In 6 days that would be 300 gallons or the equivalent of about ½ inch of rain. The length of time needed to replace that would depend upon the sprinkler and water pressure. A good type at 20 pounds pressure would need to run 2 or 3 hours.

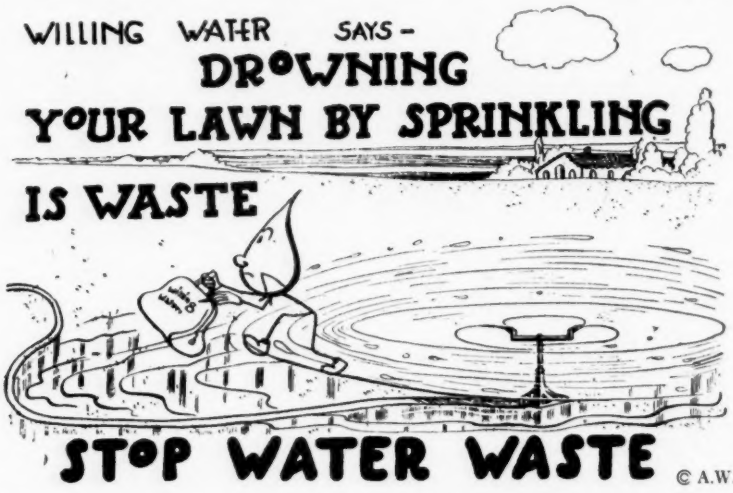
In the case of a sandy soil, the moisture loss should be replaced long before it amounts to as much as a half inch of rain. Even though such soils absorb water quickly they actually hold less moisture and lose it more readily. They need to be watered more frequently, but in smaller quantities.

It is easy to check the delivery of a sprinkler over any given time by placing coffee cans under the spray and measuring the depth of water collected. The cans should be deep enough that water does not splash out of them.

To be sure of complete coverage it is necessary to overlap the borders of the areas covered by the spray.

Pouring water on a lawn in the summer will not make up for lack of plant food or other deficiencies in the maintenance program. Neither will it restore all browned turf. Perhaps the browning was caused by a fungus disease, beetle grubs, chinch bugs, or injury from a dull or poorly adjusted lawn mower.

The soil is always the key to watering. If it has been kept reasonably



moist and the grass still turns brown, then watering alone is not the remedy.

The home owner can easily plan the correct watering program for his own lawn. The important thing is to start watering when the top inch or so of soil begins to dry and moisten it to that depth. By examining a plug of soil occasionally during watering it is easy to determine when enough moisture has been applied. The time required can be a guide to future waterings.

Watering Fallacies

Many people inquire if chlorine and other chemicals used in purifying city water are harmful to grass. If water is suitable for human consumption or even for laundry purposes, it is not likely to hurt grass. It is doubtful if enough such water would ever be put on a turf to cause any appreciable concentration of chemicals. The lime in some water may tend to alkalinize soils but never harmfully so.

Some folks seem to think that grass plants absorb water through their blades and stems. This is possibly due to the fact that grass looks so much fresher right after watering. Actually grass can make use of moisture only by taking it up from the soil through the roots.

There is widespread belief that to water during the heat of the day may result in "scalding" the grass. In fact the water has a tendency to cool rather than burn. Those who say that water drops act as millions of small lenses magnifying the heat of the sun, forget that the drops evaporate before any such burning could result. If damage to the lawn occurs after watering, look to some other cause. The important thing is to put on the right amount of water and this may be done at any convenient time of the day.

Careful tests have shown that cold well water, or warm tank water will not harm grass. Even ice water or boiling water would be close to air temperature by the time it passed a few feet of hose onto the lawn.

The common pest, Crabgrass, is called watergrass by many because they associate it with watering and think "sprinkling" brings it on. Actually, Crabgrass will grow in drier soils than will desirable grasses but like most plants it also enjoys abundant moisture. People don't notice it until well into summer, probably soon after they start watering, hence the association.

Special Problems

Shallow Roots: It is not uncommon for turf on heavy soils to suffer because of too much water, particularly following a very wet spring. In such cases the soil becomes water-logged and the deeper grass roots die for want of air. The grass must then depend upon the surface soil for its entire water and food supply. The surface dries rapidly so unless moisture is provided at frequent intervals the grass suffers even though there is saturation within an inch or so of the surface. The only way to overcome the damage is to nurse the grass along by daily watering with a fine spray. As the excess water drains from the soil, the grass roots will go down and watering can be less frequent.

A similar program may be necessary for grass suffering from an attack of grubs, chinch bugs or other insects. Such grass will have a weakened root structure which needs to be nursed back to health.

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Municipal Regulation and Sanitary Control of Water for Refrigeration and Air Conditioning

By Irving Reichman

Introduction

THE rapid growth of air conditioning and commercial refrigeration has necessitated a revision of practice in certain branches of municipal planning and control. "Effect of City Water and Sewerage Facilities on the Market for Air Conditioning Equipment" is the subject of a recent investigation by the U.S. Department of Commerce (Market Research Series 16, 17). Many sewerage systems which were built before air conditioning became a design factor have today become inadequate. The situation is even more serious in regard to the water supply. A city-wide survey, made in 1937 by the New York City Department of Water Supply, Gas and Electricity, showed that during the 100-day air conditioning season of that year an estimated 1,600 installations discharged about 34 mil.gal. of city water to the sewer daily. A rapidly growing demand for refrigeration and air conditioning and the seriousness of recent water shortages have made it necessary for the City of New York to institute additional rules and regulations governing the use of water for such installations. For instance, Rules 45 and 46 (Dept. of Water Supply, Gas and Electricity—Rules and Regulations, 1940) provide that:

Refrigeration and Air Conditioning

45. No new installation of refrigerating or air conditioning equipment requiring the use of water shall be installed on any premises supplied from the municipal system until a permit authorizing such installation has been issued by the department.

Applications for permits shall specify the make, type and tonnage of installation, the minimum and maximum water requirements and such additional information regarding the proposed installation as may be required by the department.

Where the minimum rate of water required for the operation of the apparatus exceeds one-half gallon per minute, the supply shall be metered.

Where the minimum rate does not exceed one-half gallon of water per minute, the supply shall be metered or charged for on an annual rate basis subject to the discretion of the department.

Air Conditioning

46. No individual or collective air conditioning system installed on any premises for a single consumer shall be permitted to waste annually more than the equivalent of a continuous flow of five gallons of city water per minute.

All individual or collective air conditioning systems installed on any premises for a single consumer using city water annually in

A contribution by Irving Reichman, Inspector of Water Consumption, Dept. of Water Supply, Gas and Elec., New York, N.Y.

excess of the equivalent of five gallons per minute shall be equipped with a water conserving device such as economizer, evaporative condenser, water cooling tower or other similar apparatus, which device shall not consume for makeup purposes in excess of 15% of the consumption that would normally be used without such device.

Any individual or collective group of such units installed on any premises for a single consumer with a rated capacity of 25 tons or more, or water consumption of 50 gallons or more per minute, shall be equipped, where required by the department, with a water meter to register separately the consumption of such unit or groups of units.

Under Rule 48, "The department reserves the right to restrict or prohibit extraordinary use of water if water supply conditions so require." In addition to the above, there are rules governing charges for water-consuming refrigeration and air conditioning equipment, and others which provide for the sanitary protection of the water supply.

Water usage inspection of refrigerating and air conditioning plants and equipment is chiefly for the purpose of: (1) records; (2) investigations of complaints, protests, petitions, etc.; and (3) special surveys.

Under Rule 45, all proposed water-consuming refrigeration and air conditioning installations must be recorded with the Dept. of Water Supply, Gas and Electricity. Forms furnished by the department are filed by the contractor or owner, after which inspection of the equipment is made and the information regarding water use recorded. The sample inspection reports which will be discussed later are mainly for the purpose of record. Changes in metering and unusual changes in consumption (Abnormal Increase or Abnormal Decrease, known as AI or AD) are investigated, as are complaints about pressure and quality of water, "high bill" protests, petitions for additional supply, meter test, etc. Refrigerating and air conditioning units connected to unmetered supplies are checked for capacity in order to establish water charges; frequently plants are inspected for water usage to determine the charge for a non-registry or a pre-metering period.

Special surveys include those for water conservation and sanitary protection. Under the provisions of Rule 46 it may be necessary to determine whether or not a water-conserving device is required. The quantity of water equivalent to "five gallons per minute annually" is 5 gpm. $\times$ 525,600 min. per yr., or 2,628,000 gal. (350,400 cu.ft.) per yr. When the annual air conditioning consumption exceeds this value the installation of a water-conserving device is required. With separately or independently metered systems the annual consumption may be obtained directly from the meter index sheet or record. Where the water is supplied through a general service meter it is necessary to determine separately the total air conditioning water demand. Inspections involving violations and their corrections are treated in subsequent sections.

Following is a summary of the more common uses and applications of water in refrigeration and air conditioning:

1. Compression Refrigeration System
   a. Condensing, make-up, compressor and engine-jacket cooling.
   b. Oil cooling in centrifugal compressors.

2. Absorption Refrigeration System
   a. Steam for generator heating and liquor pump motive power.
   b. Condensing, absorber, weak liquor rectifier cooling.

3. Commercial Ice Manufacture

a. Refrigeration uses (*see* 1), including air cooling and ice thawing.

b. Ice-making (can water), treatment solutions, filter washing.

4. Water Vapor Refrigeration Systems

a. Steam for booster and air-ejector operation in steam jet units or for power in steam turbine-driven centrifugal units.

b. Condensing, air-ejector cooling.

c. Chilled water make-up.

d. Compressor and vacuum pump-jacket cooling and oil cooling in centrifugal units.

5. Miscellaneous

a. Air Conditioning—washing, cooling, humidification, dehumidification of air.

b. Adsorption System—pre-cooling, after-cooling of air.

c. General Plant Utility—cleaning condensers, cooling towers, air washers, etc. (1).

Water Inspection Procedure *

The inspector or other person assigned to refrigeration and air conditioning work should equip himself with the following: a pocket thermometer (to include the range between 30° and 120°F.) for obtaining condensing water temperatures, a stop watch for timing flows, and a measuring container for measuring flows. (The author prefers an ordinary waxed-paper milk container with the top completely cut out and holding exactly one quart. Such a container is light and can be folded partly flat to save space in the kit. One-gallon and five-gallon containers are sometimes required and may usually be found on the job, or any bucket or convenient utensil may be calibrated with the quart container.) A pressure gage (0–150 psi.) and a 6-ft. rule for measuring elevations, tank volumes, etc., are necessary for certain jobs. A red pencil for noting violations, a screw driver, a pair of pliers, and a focusing flashlight, which is best for tracing overhead lines, should always be in the kit. Of course it is necessary to carry only the equipment needed for any particular job. *A word of caution:* the inspector must not lose sight of the fact that he is often in dangerous surroundings. To work around moving machinery—belts, flywheels, fans, crankshafts, or at a cooling tower or evaporative condenser up on a roof or structure—calls for awareness and caution.

Where premises are supplied through more than one meter it is advisable, before leaving the office, to note meter locations and coverage, thereby saving time in the field. On a special ice plant inspection the meter-reading sheets or the record should be consulted and the separate monthly consumptions, for the past several months or, if necessary, the past complete year, noted.

An inspection procedure along the following lines has been satisfactorily used and is recommended: The inspector should first contact the plant superintendent, operating engineer, theatre manager or any individual in charge of plant or premises, and explain the purpose of his visit. Sometimes the right of inspection is questioned, in which case the department regulation which makes such inspection mandatory may be cited. All water-consuming equipment coming

* The inspection procedure and the method of reporting related herein, have been largely developed by the author, and all material presented herein is upon the author's personal responsibility and not as official information, routine or procedure of the Dept. of Water Supply, Gas and Elec.

under the inspection is listed in a field notebook or on one or more identified sheets of paper. As each piece of equipment is examined for water connections and water usage, violations of department rules connected therewith should immediately be noted, preferably by writing the word *Violation*, underscored in red for easy identification, next to the listed machine or apparatus, and then stating the violation.

After listing the equipment, information is obtained from the operator concerning refrigerant, refrigeration load, operating season (especially necessary in air conditioning inspections) and other pertinent information depending on the requirements of the particular inspection.

Meter Coverage

Metering and the city water circuit may be checked separately or at the time the equipment is examined. A record is made of meter coverage, inter-connections are noted, etc. Fire-line meters have been found to supply large condensers and other equipment, a condition which, for obvious reasons, is prohibited. However, a cooling tower make-up supply, fed from a standpipe system gravity tank, has been allowed because the supply was taken at a level above the minimum volume required under fire department regulations. The city water circuit is checked from the meter or service to all points of use, carefully noting cross-connections to any other supply or to a drainage system, and designating such cross-connections as violations.

Determination of the city water demand for the equipment or process is the next or a simultaneous step in the inspection procedure. Where there is no re-circulating system the condenser demand is determined by timing the discharge flow with stop watch and measuring container, the container size depending on the discharge rate. Where the discharge is not measurable in this manner, because of some obstruction or other condition, the consumption rate may be found by timing the meter. The meter must, of course, register only the condenser flow; all others are kept temporarily shut off—a condition which is not always attainable. Another method of measuring discharge indirectly is computation by the following formula:

$$\text{Gpm.} = \frac{30 \times \text{Refrigerating capacity in tons}}{\text{Water temperature difference in °F.}}$$

This gives only an approximate value and is applicable when the operating tonnage is known and the condenser inlet and outlet water temperatures are obtainable. Where a piece of equipment is independently metered, however, it is necessary only to time the meter. In cases where a meter registers two simultaneous flows, one of which is separately measurable, the other may be obtained by difference.

Rate of Flow Tests

The measurement of make-up for evaporative condensers and cooling towers is usually a simple matter. The quart container is most useful for evaporative condensers and a 1-gal. container for cooling towers. The quart container will also be found handy for measuring the discharge from fractional tonnage commercial refrigerating units. Where a large meter is found to cover a single small flow, e.g., a 2-in. meter supplying an evaporative condenser and nothing else, a rate-of-flow test to check meter accuracy should be made. Rate-of-flow tests and meter slippage are

treated in fuller detail in the next section.

All necessary water usage measurements are made according to the special requirements of each job. Water derived from private sources, such as wells, ponds, etc., is not to be itemized with the municipal water demand. It is expected that the inspector will be practical in following the order of procedure outlined. When, for example, he climbs up to a cooling tower to check its connections, he should at the same time, if necessary, check for metering and measure the make-up. A little planning and ingenuity will save time and labor.

On an ice plant job, where required, and after all necessary measurements have been made, calculation of the water conversion factor follows. The conversion factor is an index of ice plant water economy, may be defined as the ratio of the quantity of water converted into ice to the total quantity of water consumed during the same period of time. In terms of tons of ice produced and cubic feet of water consumed, the conversion factor (2) may be expressed as follows:

$$\text{Conversion Factor} = \frac{\text{Actual tons of ice} \times 32}{\text{Total water consumed in cu.ft.}}$$

Experience has proved the advisability of figuring the conversion factor directly on the job in the presence of the operator who is also to be given a clear and simple explanation of the significance of the conversion factor and the method of computation. Explanations of this and other water items in air conditioning and refrigeration have served to make many friends for the water department among plant engineers, company officials and others. In making suggestions the inspector is necessarily limited by the extent of his knowledge and experience, and above all he must hold himself within the bounds of responsibility imposed by his position.

Upon completion of an inspection the field notes are put in order and transcribed onto the official inspection report form.

On larger jobs, when the inspection is completed and where advisable, the inspector should explain carefully and patiently all violations to the engineer or person responsible, taking special care to point out the seriousness of pollution hazards because of cross-connections, submerged inlets, back-flow, etc. Finally, in each case, he should indicate the accepted method or methods of correction. Simple sketches are helpful. Experience has proved that such preliminary discussion of violations often saves later misunderstandings, especially in cases involving explanatory correspondence between the department or the plant superintendent and the company home office. Where the need for correction is questioned, the inspector might discreetly remind the owner or his representative that the water department makes every effort to furnish an adequate and acceptable supply of water, but at the same time the department requires all consumers to co-operate in keeping the public supply in a pure and wholesome condition by eliminating all hazards, actual or potential.

The contents of inspection reports vary with the particular requirements. Following are typical examples:

Inspection Report

Premises: New York City

Owner: Ice Company

Requirements: Check ice plant for water usage

Type and Description of Water-consuming Equipment:

No.	*Item*	*Remarks*
5	90-ton	All refrigerant compressors water-jacketed. Discharge to air washers.
3	75-ton NH_3 Compressors	
3	40-ton	***Violation:*** No relief valve in direct supply line to compressor jackets.
10	Vertical Shell-and-Tube Condensers	
3	Air Compressors (water-jacketed)	***Violation:*** City supply cross-connected to compressor jacket discharge line feeding air washers.
3	Air Washers	
1	Oil Separator-Heat Exchanger	Oil is separated from high-pressure ammonia by chilling with water from the cooling tower system. Outgoing water discharges to dip tanks. ***Violation:*** City supply cross-connected to cooling tower recirculating supply to oil separator.
6	Dip Tanks	Discharge from oil separator or condenser pit used for thawing.
4	Pressure Filters	***Violation:*** Filter drain line directly connected to soil line of building drainage system.
1	Atmospheric Cooling Tower	Make-up for both towers into condenser pit. Also a direct, over-rim auxiliary supply.
1	Forced-Draft Cooling Tower	Suction from condenser pit, discharge to towers, oil separator, dip tanks.
4	Cooling Tower Circulating Pumps	***Violation:*** Direct city priming connection to pump discharge manifold.

Refrigerant: Ammonia—20,000 lb.

Operating Season: 365 day 24- hr. day

Ice Production (1940): 108,500 tons (actual)

Metering: E.P. (Entire Premises) metered by 2 meters, inter-connected through the supply line to the compressor jackets; supplies are check-valved.

Water Circuit:

3-in. Meter
- High-Pressure boilers
- Direct, over-rim auxiliary condensing supply
- Compressor Jackets → Air Washers → Condenser Pit → Cooling Towers → Oil Separator → Dip Tanks

4-in. Meter
- Sanitary, Utility
- Ice-making Supply — Filters — Precoolers — Can Fillers
- Compressor Jackets, etc. (same as above)

Water Consumption (1940):

		cu.ft.
Through	3-in. Meter	1,806,000
Through	4-in. Meter	4,412,000
Total Registered Consumption (1940)		6,218,000

$$\text{Conversion Factor (1940 Gross Annual)} = \frac{108{,}500 \times 32}{6{,}218{,}000} = 0.558 \text{ or } 55.8\%$$

Violation	*Recommended Correction*
1. No pressure relief valve in direct supply line to ammonia compressor cooling jackets.	1. Relief valve shall be set on inlet side of compressor jacket water distribution manifold.
2. Cross-connection between city supply and compressor jacket discharge line to air washers.	2. Cross-connection shall be entirely removed. If required, a separate supply to the air washers will be allowed through an over-rim supplied surge or suction tank.
3. Cross-connection between city supply and branch from cooling tower recirculating system to oil separator.	3. Correction same as 2 above, except that indirect supply shall be to oil separator.
4. Filter drain directly connected to soil line of building drainage system.	4. Drain line shall be disconnected from soil line and shall be made to discharge at least 2 in. above the overflow rim (flood level) of an open receptacle.
5. Direct city priming connection on discharge side of cooling tower circulating pumps.	5. Direct priming connection shall be entirely removed. If required pumps may be primed indirectly through either or both of the cooling tower basins by equipping the latter with separate, over-rim supply inlets, or as under 2 above.

The foregoing report covers a fairly large plant. The boiler water demand accounts for most of the non-refrigeration water entering into the conversion factor. The conversion factor is a mean annual value; the summer conversion is generally lower and the winter higher than average. In regard to violation corrections, the owner may, within reasonable limits, be permitted to substitute for any recommended correction one which is equally good. Several violations, each requiring the same correction, are frequently satisfied by a single installation. For instance, if each of three separate violations requires the installation of a suction tank, a single tank, properly connected, may satisfy the requirements.

Inspection Report

Premises: New York City

Owner: Brewing Company

Requirements: Check refrigerating plant for water usage

Type and Description of Water-consuming Equipment:

No.	*Item*	*Remarks*
1	100-ton	
3	50-ton NH_3 Compressors	All compressors water-jacketed.
1	35-ton	
2	Shell-and-Tube Condensers	Well water supplies. ***Violation:*** Cross-connection between well and auxiliary city supplies.
2	Well Water Pumps	***Violation:*** Pump shaft seals directly city supplied.

Refrigerant: Ammonia—3100 lb.

Operating Season: 365 day—24 hr. day

Metering: Refrigerating plant not separately metered; entirely covered by 3-in. meter, which also covers part of the brewery equipment.

Water Consumption (City supply):

	gpm.
Compressor Jackets	2.5
Pump Shaft Seals	(negligible)
Normal Total City Demand	2.5 (discharged to waste)

Note: The auxiliary city condensing supply is a plant essential.

Violations	*Recommended Corrections*
1. Cross-connection between city and well water supplies at condenser inlets.	1. Cross-connection shall be entirely removed. If required, city water to the condensers will be allowed through an over-rim supplied surge or suction tank.
2. Well pump stuffing-box seals directly connected to city water supply.	2. Direct connection to the city supply shall be removed. An indirect supply to the shaft seals will be allowed through an over-rim, or an approved, anti-siphon ballcock supplied tank or receptacle.

Inspection Report

Premises: New York City

Owner: Theatre

Requirements: Check air conditioning system for water usage as per Rule 46

Type and Description of Water-consuming Equipment:

No.	*Item*	*Remarks*
1	150-ton, CO_2 Compressor	
1	Double-pipe Condenser	
2	Chilled-water Air Washers	Total basin capacity 2,000 gal.—drained, washed and refilled twice a month during season.

Refrigerant: Carbon Dioxide—2,800 lb.

Operating Season: 1938, 1,030 hr.; 1939, 1,100 hr.; 1940,1,050 hr. Avg. past 3 yr., 1,060 hr. per ann.

Metering: Air conditioning system separately and entirely metered by 3-in. meter.

Water Consumption:

	gpm.
Mean Condenser Demand	240
Air Washer Demand	negligible
Total Demand	240 (100% wasted to sewer)

$$\text{Mean Annual Rate of Discharge to Waste} = \frac{240 \times 60 \times 1060}{525{,}600 \text{ min. per yr.}} = 29.04 \text{ gpm. annually}$$

Note: No water-conserving equipment. The annual discharge rate exceeds the 5 gpm. annually allowed under Rule 46. This is supported by department record, showing:

Air Conditioning Water Consumption

Year	*cu.ft.*
1938	1,995,000
1939	2,126,000
1940	2,037,000

Because of the refrigerant's low condensing temperature, carbon dioxide systems consume a comparatively large amount of water, even when equipped with water-conserving devices. Such a device would have to be installed on the above job as required under Rule 46.

Without a water-conserving device the maximum annual air conditioning water consumption allowed is 350,400 cu.ft., regardless of the plant's refrigerating capacity. After the water-conserving device is installed the make-up demand may not exceed 15 per cent of the normal demand, yet it can readily be seen that with a water-conserving device the permitted make-up may exceed the 5 gpm. or 350,400 cu.ft. annually allowed without such device. For example, assume a job having a normal demand of 300 gpm. Upon installing a water-conserving device the make-up permitted would be 15 per cent × 300 or 45 gpm., which is equivalent to 3,153,600 cu.ft. per year, or nine times the consumption allowed without water saving. This figure is admittedly large but it is factual, since the rule is set up on a per annum basis; but no cooling plant is assumed to run continuously for every minute of the year. However, there is no conflict between the provisions of the rule. The first sets the requirement for the installation of water-saving equipment, the second governs the minimum amount of water that must be saved, namely, 85 per cent. The 5 gpm. or 350,400 cu.ft. per year should not be looked upon as a maximum consumption or limiting value, but as a dividing line. Without water saving, the loss or waste, regardless of the demand, may be 100 per cent; with it, not more than 15 per cent.

Inspection Report

Premises: New York City

Owner: Department Store

Requirements: Check air conditioning system for water usage as per Rule 46.

Type and Description of Water-consuming Equipment:

No.	*Item*	*Remarks*
1	150-ton Centrifugal Refrigerating unit	
1	Induced-Draft Cooling Tower	***Violation:*** Submerged inlet.

Refrigerant: Carrene No. 2—600 lb.

Operating Season: Average 90 day—9 hr. day

Metering: Refrigerating unit not separately metered but covered by 2-in. meter. Cooling tower separately metered by $\frac{3}{8}$ in. meter.

Water Consumption:

	gpm.
Oil Cooling Demand	3.3
Mean Cooling Tower Make-up	4.2
Total Demand	7.5

Normal Demand = $2 \times 150 = 300$ gpm. (*See below*)

Make-up in Per Cent of Normal Demand $= \frac{4.2}{300} \times 100 = 1.4\%$

Total Demand in Per Cent of Normal Demand $= \frac{7.5}{300} \times 100 = 2.5\%$

Violation: Submerged make-up supply inlet on cooling tower basin.

Recommended Correction: Inlet shall be raised at least 4 in. above overflow rim of basin.

Inspection Report

(*Standard Commercial Refrigeration Form*)

Premises: New York City

Owner: Market

Requirements: Check refrigerating unit for water usage

1. Portion of premises and equipment refrigerated: Walk-in box and display case

2. Metered water used? Yes If so, give data: Metered by 1-in. meter.

3. Separate or house supply? House

4. Any supply other than city? No If so, give details:

5. Is water recirculated or discharged to waste? Discharged to waste

6. Per cent recirculated or discharged: 100%

7. Refrigerating Machine: Manufacture: (1) ——— condensing unit

Tonnage: 1½ Refrigerant: Freon 12 Lb. : 22

8. Quantity of water used per minute, in gallons: 2.1

9. Operating Season: Days per yr.: 365. Hr. (avg.) per day: 12

10. Have check and relief valves been installed? Check valve installed; no relief valve

11. Has discharge line been properly installed? Yes

12. Is metering or separate meter required? Properly metered

Violation: No pressure relief valve in supply line to refrigerating unit

Inspection Report

Premises: New York City

Owner: Delicatessen

Requirements: Check refrigerating unit for water usage

1. Portion of premises and equipment refrigerated: Storage box, counter tray, display case

2. Metered water used? No If so, give data:

3. Separate or house supply? House

4. Any supply other than city? No If so, give details:

5. Is water recirculated or discharged to waste? Discharged to waste

6. Per cent recirculated or discharged: 100%

7. Refrigerating Machine: Manufacture: (2) ——— condensing units

Tonnage: ¼ each = ½ ton total Refrigerant: Methyl Chloride—6 lb. each

8. Quantity of water used per min., in gal.: 0.4 each = 0.8 gpm. total

9. Operating Season: Day per yr.: 365, Hr. (avg.) per day: 6

10. Have check and relief valves been installed? Check valve installed
Relief valve not required

11. Has discharge line been properly installed? Yes

12. Is metering or separate meter required? (*See Remarks*)

Remarks:

Estimated Annual Consumption $= \frac{0.8 \times 60 \times 6 \times 365}{7.5} = 14{,}000$ cu.ft. @ \$1.50 per M,

Estimated Revenue = 14,000 × \$1.50 or \$21.00 per annum as against \$15.00 annual charge.

In New York City individual refrigerating machines consuming not more than 0.5 gpm. may be charged for on an annual rate basis. Unmetered machines are quite common and it is often, though not always, advisable to meter them, not for additional revenue alone but to reduce water waste through defective regulating valves. The latter are often ignored where the supply is not metered.

The "normal" water demand referred to in Rule 46 is an arbitrary rate of water consumption established at 2 gpm. per ton of refrigerating capacity—not necessarily the installed capacity. This accepted normal demand is almost invariably higher than the actual demand. At any rate it is liberal enough, and any piece of equipment or apparatus worthy of being classed as a "water-conserving device" should easily fall within the 15 per cent limit for make-up or total demand.

The inspector must exercise judgment in evaluating jobs that appear to require water-saving equipment. The following case illustrates the point in question: Inspection covered a small motion picture theatre with a total installed capacity of 60 tons, comprising two separate condensing units, one 20-ton and one 40-ton. The 20-ton unit consumed 28 gpm.; the 40-ton, 54 gpm. The mean yearly operating season was 100 days at 8 hr. average daily. The machines were run as follows: the 20-ton unit was run about half the total time and the 40-ton the other half. Since the theatre was amply taken care of by the 40-ton unit alone (two machines were installed for the sake of flexibility and better operating economy) it was seldom necessary to run both machine together,—at most a few hours a year, under conditions of a packed house and extremely humid weather—and this short period may be ignored. If computed on the installed capacity, the Annual Discharge Rate would be:

$$\frac{(28 + 54) \times 60 \times 800}{525{,}600} = 7.5 \text{ gpm.}$$

Since only 5 gpm. annually is allowed, the theater owner would be required, on this basis, to install water-saving equipment. However, the capacity in use was not $(20 + 40)$ tons but $\frac{(20 + 40)}{2}$ or 30 tons, and the actual Discharge Rate, 3:75 gpm. annually.

Complications like the above make it difficult to rate an air conditioning job. In the case just cited the air conditioning supply was not separately metered but came through the house or general service meter. Checking back readings covering three operating seasons substantiated the 30-ton figure. A practical solution in cases like the foregoing is to order separate metering and then to be guided by the an-

nual consumption. The third clause in Rule 46 provides for this.

A number of commercial refrigerating units and small air conditioning units consume less than the normal or usual water requirement for their capacity. Under New York City rules the supply for an unmetered refrigerating machine equipped with a water-conserving device, i.e., one which consumes not more than 15 per cent of the consumption that would normally be used without such device, is chargeable at only 15 per cent of the current rate of $30 per annum per ton of refrigerating capacity. For example, an unmetered supply for a ½-ton machine is charged for at $15 per year, but if classifiable as an approved water-conserving device, the charge for a machine of the same capacity would be only $2.25 per year. The annual consumption in per cent of normal demand will show whether the machine may be classed as a water-conserving device, and the estimated annual consumption will show whether or not separate metering is advisable. To illustrate:

Capacity: ¾ ton
Water Demand: 0.25 gpm.
Operating Season: (mean ann.) —365 days @ 7 hr. avg. daily = 2555 hr.
(water-cooled)—120 days @ 12 hr. avg. daily = 1440 hr.

$$\text{Estd. Ann. Consumption in Per Cent of Normal Demand} = \frac{0.25 \times 60 \times 1440}{(\frac{3}{4} \times 2) \times 60 \times 2555} \times 100 = 9.4\%$$

not over 15 per cent, therefore classifiable as a water-conserving device.

$$\text{Estd. Ann. Consumption} = \frac{0.25 \times 60 \times 1440}{7.5} = 2880 \text{ cu.ft. (approx.)}$$

Estd. Ann. Revenue (if metered) = 2880 cu.ft. × $1.50 per M = $4.32
Estd. Ann. Revenue (if not metered) = ¾ × (15% × $30.00) = $3.38

It is obvious that the difference between metered and fixed-charge revenues may vary depending on refrigerating capacity, water demand and operating time. Unmetered jobs, call for individual appraisal. Where the estimated revenue exceeds the fixed annual charge it is best to meter the supply. It is the author's opinion, based on experience, that separate metering is sometimes to be avoided. For instance, in the case just cited, the slippage loss that would very likely be incurred by the small rate of flow (0.25 gpm.) would, in time, offset any gain from metering, even were a ⅝-in. meter installed. Where the delivery demand falls below the minimum normal test flow limit of a meter (A.W.W.A. or N.E.W.W.A. Standard Specifications) separate metering is generally not advisable. The supply in such cases may be taken from a general service or house meter, and in unmetered premises a flat rate or fixed charge is preferable to separate metering. These last remarks apply not only to water-conserving units with low demands, but to straight water-cooled units as well. Many fractional tonnage jobs exist in which the water consumed is either not registered by the meter or is under-registered. The foregoing remarks concerning unmetered equipment and charges do not apply, of course, to cities or communities in which all accounts are metered.

On the question of meter slippage, investigations show that many water meters now in service are oversize. The granting of permits to set 3-, 4- and 6-in. disc and turbine meters for air conditioning reflects, in many in-

stances, a policy of over-generous cooperation. By requiring that applications for all proposed refrigeration and air conditioning installations be submitted, the water department can investigate the requirements of each job and then allow the size and type meter appropriate for the operating demand.

Experience has proved the need for a meter check-up in cases where there has been a marked reduction in water demand as, for example, where a water-conserving device has been added to an existing installation. Meters both small and large, but more commonly the latter, have been found to under-register because of slippage due to a lessened demand and a correspondingly reduced rate of flow. Slippage represents water passing through the meter but not registered by it. Rules and Regulations † for New York City with respect to reduction in the size of meter state:

> Where inaccuracy of registration is found to be due to the improper size of the meter, such meter shall be replaced with a smaller meter of a size to be designated by the department. When such reduction of meter size is effected, the piping of the meter setting from the inlet valve to the outlet valve shall be of the same size as the meter.

The following cases are typical and illustrate two of a number of conditions which may lead to under-registration:

1. A 6-in. turbine meter was originally set to cover a carbon dioxide cooling system having a water demand of 300 gpm. The meter was tested under service conditions and was found to register accurately, that is, within the allowed limits for accuracy. Eight years later the plant was replaced by a Freon job of larger tonnage but having approximately the same water demand. Directly after this change the meter was again tested and found accurate. The following year a mechanical cooling tower was added to the plant and the total demand (make-up) dropped to about 5 gpm. A rate-of-flow test on the meter under the new service conditions showed a slippage loss of over 83 per cent. The turbine meter was ordered to be replaced by a small disc meter.

2. A 2-in. disc meter was set in a new building in 1937 to cover separately a future air conditioning installation for a small theater. At the time a shell-and-tube condenser job was contemplated but no definite decision was made. The department, upon the architect's request, allowed the 2-in meter. The cooling plant was not installed until the summer of 1941, and with an evaporative condenser instead of a shell-and-tube. A rate-of-flow test on the meter turned out as follows:

Actual Rate of Flow — 0.46 gpm. (measured)

Meter Registration Rate — 1.0 cu.ft. in 20.6 min.

Apparent Rate of Flow — $\frac{7.48}{20.6} = 0.363$ gpm.

$$\text{Slippage} = (0.460 - 0.363) = 0.097 \text{ gpm. @ } 0.46 \text{ gpm. rate of flow}$$

$$\text{Per Cent Slippage} = \frac{0.097}{0.460} \times 100 = 21.1\%$$

or, in terms of meter accuracy, $\frac{0.363}{0.460} \times 100 = 78.9\%$ accurate

† New York City Dept. of Water Supply, Gas and Electricity Rules and Regulations, Rule 113 (1940).

The meter was ordered removed and the required supply taken from a branch of the metered house line.

As stated previously, there are a number of possible changes which may result in a reduced rate of flow and this in turn may give rise to under-registration. Such changes are best checked. Admittedly, the meter slippage or rate-of-flow test made by the inspector in the field using stop watch and container, though fairly accurate, may not be as accurate as a bench test. However, if performed with care, the field test fulfills its purpose in showing important discrepancies and has a practical advantage in being made under actual service conditions. The routine field test for meter accuracy using a comparison test meter is not always suitable where low rates of flow are involved.

An owner or contractor installing water-consuming refrigeration or air conditioning equipment in New York is required, under Rule 45, to submit application forms covering the installation. Where premises are entirely metered the question of revenue is automatically taken care of, but where a job is installed in unmetered premises or in an unmetered portion without the department's knowledge, a revenue loss of $30 per ton per annum is sustained by the city unless discovered. A good number of unrecorded, unmetered machines have been picked up on routine inspection. Water supply plumbing in New York City must be done by licensed plumbers who are required to file for each new installation or correction job. Upon completion, this work is inspected and put on record. An exception is made under current Building Code regulations allowing plumbing on refrigeration and air conditioning jobs, within a distance of 15 ft. of the apparatus or equipment, to be done without a license, and therefore without a permit. There would be no difficulty here if all contractors filed the required installation forms for every job. The privilege granted refrigeration and air conditioning contractors to do their own plumbing carries with it the obligation to notify the water department of all installations made. Unfortunately some contractors have failed to meet this obligation, a situation which compels more stringent regulation.

The filing of forms is required not only on new installations but also on replacements and other changes in existing equipment which may affect water consumption or the water-supply connections. On unmetered jobs the completion date is essential information, and even where the supply is fully metered it may become necessary to know installation dates. The following cases illustrate this point:

A confectioner's house meter covered a comfort cooling system having an average condenser demand of 36 gpm. Some time between regular end-of-month readings (July 31–Aug. 31) the meter stopped registering. A repair notice was served on the latter date. During the same month (August) the owner had an evaporative condenser installed as a replacement, and because the contractor failed to report the work, the department had no knowledge of the date of change-over from shell-and-tube to evaporative condenser. At the end of the statutory period the owner received a bill from the city collector covering the non-registry period (July 31 to date of meter reset), the estimated charge having been based on a previous, presumably equivalent, calendar period. The owner protested

the charge as excessive, contending that since he installed the evaporative condenser the water consumption was not as great as that of the previous season, which, as a matter of fact, was true. After inspection of the new equipment for water demand, and checking with the installation contractor as to the completion date, a satisfactory adjustment was made.

Check on Waste

A second example was the case of an ice cream manufacturer who replaced his shell-and-tube condensers by an evaporative condenser in order to reduce his water bills. No forms were submitted. Because of the plant operator's inexperience with the new condenser, the water-conserving device did not save a penny's worth of water. The trouble, which led to unnecessary waste, was discovered while investigating the "high bill" complaint. However, had the forms been sent in as required, and at the proper time, the inspector would very likely have spotted the trouble when determining the water demand and he would then have called the owner's attention to the unnecessary waste. These case examples show that aside from the water department's interest, the proper filing of forms may prove of benefit to the owner.

Similar to the standard commercial refrigeration inspection form is one covering air conditioning installations, such as self-contained and small central units. There is an additional question on water-saving equipment. The reader is again reminded that the foregoing sample inspection reports constitute an incomplete but fairly representative cross-section of regular inspections.

Sanitary Violations and Their Correction

The sanitary inspection of water-supplied refrigeration and air conditioning equipment is an essential part of the inspection procedure. Most of the violations have been noted in the preceding section and their correction indicated. The following is largely in the nature of a recapitulation as well as an exposition of the why and wherefore of sanitary violations on water-supplied refrigeration and air conditioning equipment.

Without departing from the general topic, it may be well at this point to clear up a difficulty which arises, not so much on refrigeration jobs as in other branches of water consumption, and frequently enough to demand serious attention. There are still many individuals who contend that because they pay for water they may use it in any manner they please, just as they would any other purchased commodity. To this the water department has no objection—provided there is no waste and the water has left the supply piping and is no longer in physical contact with the city main. The department is obliged to exercise supervision over the use of water in all premises under its jurisdiction, which means all premises connected to the public water supply system, and such supervision is not an imposition upon the private rights of individual water consumers, but a protective function operating for the general benefit of all.

Health Precautions

The furnishing of potable water by a municipality to its citizens is not like the selling of an ordinary commodity, but it is more exactly a service, behind which are complications, responsibilities and obligations. A single back-

flow connection in a one-family dwelling may endanger the health, if not the life, of dozens and even hundreds of persons. Institutional premises, particularly hospitals, often present difficult water protection problems. The author has found that industrial establishments contain an amazing number of water-supply hazards in the form of fixtures and connections, almost all of which were installed for operating convenience, and entirely without consideration or thought of pollution. Water inspection, on the consumption end, has an important public health connection, and such inspection is justified by, and based upon, the proposition that the municipality, through its water department or water works, is responsible for providing an adequate water supply and for its protection, conservation and proper use. In New York, the City Charter and the Administrative Code provide the authority for inspectional supervision.

The water-supply violations on refrigeration and air conditioning equipment may be grouped into the following classes, corresponding roughly to their frequency of occurrence:

1. Cross-connections between a direct city supply and a recirculating water system.
2. Submerged and under-rim inlets.
3. Cross-connections between the city supply and a river, well or other non-public water supply.
4. Cross-connections between the city supply and a sewer or drainage system.
5. Refrigerant hazard.
6. Provisional cross-connections.

Cross-Connection Hazards

1. The contamination danger in cross-connections between a direct city supply and recirculating water is not commonly recognized. A popular practice is the connection of a direct city make-up line or an emergency or auxiliary condensing supply to either the suction or discharge line of a cooling tower or other recirculating water system. Such connections are admittedly convenient, but are dangerous. A cooling tower basin elevated, say 70 ft. above plant level, will develop a static pressure at the bottom of the suction line of approximately 70×0.434, or 30.38 psi. The discharge line pressure is slightly greater. Such back pressure, it is often argued, is not dangerous, since the city maintains fairly high pressures in the distribution system. With sustained average normal pressures of from 30 to 95 psi. in the city ‡ mains little is likely to happen under nominal elevation and head loss conditions. But not all municipalities maintain high main pressures, and cooling tower elevations are not readily made to order.

Emergency Connections

Furthermore, suppose some unusual occurrence happens like a break in the main; or an exceptionally large draft as at a big fire (the pumpers may suck a small main to partial depletion); or even a sudden large draft or the existence of critical pipe flow conditions within the building itself; or an emergency local shut-off in the city distribution system or even in the house system under certain conditions—at such times the development of negative pressure or a large drop in pressure is not unusual. When negative pressure or a large pressure differential develops, so that the residual city pressure is less than the static pressure in the cooling tower riser, for example, then back-siphonage and back-flow not only be-

‡ New York City.

come possible but in many cases actually occur, usually unnoticed or unrecognized.

During a routine inspection the author explained the foregoing phenomenon to a well-meaning but skeptical operating engineer, in charge of a cooling plant equipped with a forced-draft cooling tower and located in a low-pressure distribution area. The tower, which was newly installed and had not been working satisfactorily, had just that afternoon been cut out of service pending the arrival of the tower company man. It was imperative to have the plant ready by morning. During the shut-down the engineer removed a plug from a convenient tee at the bottom of the 4-in. tower suction line and made a 1-in., valve-controlled condensing connection direct from the outlet side of the water meter. The former direct connection to the condenser was removed when the tower was installed.

The operator was informed of the city's effort to maintain the purity of its water supply, and the seriousness of the emergency cross-connection was pointed out to him. He was told also that official notice requiring removal of the violation would be sent to the owner. The tower elevation was high for the local main pressure, a condition which demanded immediate attention. Two days later on a second visit, all the emergency connection piping and fittings were on the floor. The tower system was entirely bypassed and the condenser was operating directly on the city supply. Without waiting to be asked, the operator exclaimed, "Inspector, I'd never believe what you told me the other day if I hadn't seen it happen. After you left I opened that cross-connection valve, and instead of getting city water in, I heard the water in the tower line rush down, and then it began to back up through the meter. I quickly shut down the main valve, then ripped the whole thing out—just as you see. Now I'll run on straight city water until the tower is corrected—and no more cross-connections."

Contamination Hazards

Cooling tower recirculated water is highly polluted. It should be borne in mind that the powerful fan sucks in large quantities of dust, insects, airborne bacteria and other organisms, and frequently chemical fumes, all of which are washed out of the air and are either precipitated in the tower basin or become dissolved or suspended in the water. Not infrequently the recirculated water is itself directly treated with poisonous, anti-fouling compounds.

Connecting the make-up or auxiliary condensing supply to the discharge side of a cooling tower system is as dangerous as having it on the suction side. The danger is even greater, since the discharge level in the tower is higher than the suction level, resulting in a head greater than the suction head. Furthermore, the discharge head capacity of the circulating pump exceeds the static head or back pressure in the discharge riser, which means that contamination of the city supply by direct pumping into the main may be more easily possible than contamination by back-flow. The contamination hazard is not confined to make-up or auxiliary condensing supplies. One cooling plant operator, for example, was found to have installed a directly-supplied injector—a neat, home-made affair—on his recirculating system for the purpose of adding a poisonous chemical to counteract algae

growth in the cooling tower. This little gadget constituted a serious water supply hazard and its immediate removal was ordered. All devices, connections and other sources of contamination which endanger the municipal supply, should be condemned.

Violations

The method of correcting violations of the type discussed depends chiefly upon the particular structural, mechanical or hydraulic conditions. Where the tower elevation is not too great and city pressure suffices, the make-up line and, where needed (as with carbon dioxide and ammonia systems), the auxiliary supply line, may both be run directly up to and at least 4 in. above the overflow rim of the tower pan, or basin. The usual make-up inlet terminates at one side of the basin and is float-valve controlled. The auxiliary supply, actually a quick-filler, is best brought directly over, and the correct distance above, the suction or intake pipe so that fresh water may reach the condenser with the least loss of cooling effect. The regular make-up and the auxiliary may be supplied either through a single riser or through separate risers. In the latter case each riser may be controlled at basement or plant level, whereas in the former case it may be necessary to control at the tower, which is often inconvenient.

Where the cooling tower is too high to be fed under city pressure, an overrim supplied surge or suction tank with booster pump may be installed. The tank and pump may be placed in any convenient location. The pump may discharge to the tower or directly to the condenser, the latter being perferred for an auxiliary supply hook-up. In lieu of a separate booster, the circulating pump, if set in the proper location, may be connected to the suction line of the tank.

2. The use of submerged and underrim inlets can be attributed to the fact that, in the past, equipment manufacturers have not considered such inlets to be water-supply hazards, and also because operators have found them convenient. On condensers, water coolers, cooling jackets and similar closed vessels which require water under pressure, the inlets are necessarily submerged, and in all such cases the supply must be adequately protected. Where submerged inlets are not necessary for the proper functioning of the apparatus or equipment, e.g., tanks or basins on air washers, cooling towers, evaporative condensers, etc., there is no excuse for them. Indeed, within recent months, installations in New York have shown a marked decrease in all kinds of violations, particularly submerged inlets. Many contractors now specifying equipment are mindful of the necessity for water-supply protection, and even though manufacturers have not redesigned some of their products, equipment is being installed with changes meeting water department requirements. It is no longer a novelty to see a cooling tower or evaporative condenser basin, originally designed with a submerged inlet, arrive on the job with a permanently affixed gooseneck discharging 6 in. or more above the basin overflow rim.

Thaw (dip) tanks, chemical solution and water treatment tanks and other pieces of ice plant equipment are often found with directly-supplied, submerged inlets. The usual correction is to raise the inlet above the fixture flood level. On thaw tanks it is usually desirable, from the operator's standpoint, to have a submerged inlet

so that the warmer water may enter at the bottom of the tank and work its way up. With an over-rim inlet the warmer water would remain on top or be largely wasted over the tank weir, thus losing much of the ice-thawing effect. Submerged inlet dip tanks are generally fed from a directly-supplied heat exchanger, air cooler, ammonia forecoooler, etc., and in such cases the supply must be protected.

On centrifugal displacement type air compressors which require a direct supply under pressure to a vessel containing air-polluted water, the inlet side is to be protected even though the water separator has an open discharge. On direct, single supply condensers and other equipment where submerged inlets are permitted, care must be taken to avoid submerged or cross-connected outlets, so that if negative pressure develops, waste water or sewage may not be siphoned back into the supply system.

Theoretically, the minimum air gap, or vertical distance an inlet should be above the overflow or flood level rim of a fixture, should be that distance just greater than the water (siphonic) lift created by the greatest possible vacuum in the supply line. Under average conditions a height of 4 in. above the flood level rim for a cooling tower supply inlet is believed satisfactory. Federal Specification WW–P–541a requires the air gap for supply fittings under ordinary conditions to be at least twice the effective opening (3).

Pump Priming Connections Prohibited

3. Plants operating on river, pond, lake or well water are commonly found to have a number of emergency or auxiliary cross-connections to the city supply. River, pond or lake water is generally not recirculated in a water cooling system, and emergency city water is usually run to waste. Cross-connections of this type are most often found on the supply lines to condensers, ammonia forecoolers, compressor jackets, air coolers and heat exchangers, and almost invariably on the pumps. Direct pump priming connections are prohibited in New York City. Suction (vacuum) priming, or an indirect priming supply as through an open funnel, tank or other receptacle is recommended.

Another violation on river, pond, lake or well water pumps is the directly-supplied stuffing box. City water shaft seals on such pumps are cross-connections, and where the seals must be supplied with city water, a good correction is the installation of an ordinary water closet, high-flush tank with an over-rim or an anti-siphon ballcock inlet and sufficiently elevated to give the necessary pressure.

Frequently a river water intake crib is backwashed through a direct flushing connection to the pump suction line. Such cross-connections are sometimes made provisional (*see* paragraph 6). Although backwashing is done at low tide a pressure greater than that developed under gravity flow is usually required. The correction is an elevated over-rim supplied gravity tank or a suction tank and pump. This is also the correction for condensers and other equipment ordinarily cooled by river or well water and having emergency or auxiliary city water cross-connections.

Although, from the sanitary standpoint, the potable water supply is the one which must be protected, some localities also restrict the use of water supplies other than municipal. For

instance, it may be necessary to prohibit the discharging of river water into the municipal sewerage system where the system lacks the capacity to handle the volume, or where the river water might interfere with the normal sewage treatment process. Well water supplies on Long Island are regulated under the New York State Conservation Law, with the usual provision that the water, after use and if uncontaminated, be returned to the ground through a diffusion well.

Convenience Connections

4. Another example of "convenience" connections is cross-connections between the city supply and the sewer or drainage system. The hazard from this type of back-flow connection arises either from the potential danger of back-siphonage or from direct contamination through the submerged cross-connection. Condenser discharge lines, particularly on commercial units, are frequently found with submerged outlets, i.e., emptying below the overflow or flood level rim of an open receptacle, or solidly connected to the drainage system. In the latter case the commonest points of connection are either directly to a soil line, to a convenient trap or to some fixture drain. Chilled water and other water-circulating systems are frequently provided with a direct connection to the building drain. Wash-water drainage lines from city-supplied pressure filters are sometimes directly sewer connected.

The correction in all cases of direct cross-connection between the city supply and the drainage or waste water system, is disconnection of one from the other. If a direct city supply to a fixture, machine or apparatus is essential, direct connection to the sewer or drainage system is prohibited; where a direct drainage system connection is permitted, the city supply must be properly protected.

Refrigerant Contamination

5. Refrigerant in a directly-supplied, water-cooled compressor, condenser, receiver, etc., may upon internal leakage caused by failure of a jacket, tube or coil, contaminate or otherwise affect the water supply. Head pressures for refrigerants such as methyl chloride and Freon-12 may range from two to four times the usual or average inlet water pressure, and for carbon dioxide the operating head pressure may be from twenty to thirty-five times greater than city water pressure. An internal leak, causing the refrigerant to get into the water supply, may result in two kinds of hazard.

Contamination, particularly by water soluble refrigerants such as sulfur dioxide and ammonia, is a potential health or sanitary hazard. The Administrative Code of the City of New York permits the use of practically all commercial chemical refrigerants, many of which are poisonous. The second danger is the possibility of a blowout in the water supply system. With a high refrigerant charge under high-pressure, internal leakage may result in back-flow of the refrigerant into the house piping and possibly into the service and water main. Carbon dioxide carries high operating pressures (the condensing pressure is about 1,000 psi. gage), and if this or any other high pressure gas should get into the water supply system, a break or blowout of a weak joint or section, or of a lead service pipe, is not impossible.

When a break within a condenser, water-cooled receiver, cooling jacket,

etc., occurs, and a refrigerant leak develops, the high-pressure gas will seek relief by the path of least resistance, which would ordinarily be the water discharge end. For this reason it is wrong to have water-regulating valves or other water-control devices on the condenser outlet side. Under New York City rules, the water supply line to any directly-connected, refrigerant-containing apparatus or machine must be equipped with a check valve. In addition, when the quantity of refrigerant in the system is over 20 lb., a pressure relief valve must be installed in the supply line between the check valve and the unit, the relief valve to be set at 5 psi. above maximum city water pressure at the point of installation. Such protection is not required where the city supply cannot be affected by the refrigerant, as for example, the supply to an evaporative condenser.

A back-flow preventer (vacuum breaker) should not be used as a refrigerant pressure relief valve, a mistake which has been made in a number of recent installations. The intention is to have the back-flow preventer perform the double function of protecting the supply (because of the submerged inlet on the condenser) and of having the air port, or air inlet, serve as a relief vent in case of a refrigerant leak. For the first function the back-flow preventer is useful but is not required ‡ since a directly-supplied submerged inlet on a condenser is permitted as long as there is no submerged or cross-connected outlet. The second function, that of having the back-flow preventer air port or inlet serve as a refrigerant relief vent in case of a leak, is not feasible since the refrigerant might exert an opposing back pressure on the disc or operating mechanism. This would prevent the air port from opening.

‡ New York City.

Standby Supply

6. Provisional cross-connections are frequently found in plants where city water is a standby or emergency supply to the main supply from a well, pond, lake or stream. The cross-connection is usually in the form of a flanged nipple (spool), coupling, union or other fitting which is normally not connected but which may be quickly hooked up in an emergency. Such connections, once made, are dangerous and the danger may arise in one of several ways, for example:

A provisional, cross-connecting 4-in. spool, between an industrial well and the city supply in the basement of a large plant, normally hung disconnected from one of the two flanged valves separating the supplies. The well water supply line was continuous from the pump at ground level, through a heat exchanger on the second floor, to the top of the ammonia condensers on the fourth floor—a total vertical rise of about 80 ft. A pump breakdown, for example, would necessitate making the connection. The riser is full of well water and the connection valves are opened. With an 80-ft. head of water the static pressure at the bottom of the riser would be about 35 psi. If this exceeds the city entrance pressure, back-flow of well water into the city main might possibly result. Besides back-flow caused by static pressure differential, the city supply might be contaminated through the pump proper, i.e., by pumping well water directly into the main.

The provisional cross-connection is a potential water supply hazard. Fol-

lowing is a suggested regulation covering such cross-connections.

> Temporary or provisional cross-connections between the municipal water supply and any other supply through connective fittings such as unions couplings, nipples, etc., are prohibited, except as otherwise provided for in these rules.
>
> Where such cross-connection exists it shall be entirely removed and each supply made a separate and independent system without temporary or provisional connective closures, or the municipal supply shall be protected against contamination in the manner prescribed.

The best method of correcting the provisional cross-connection and at the same time retaining the advantage of standby city water is permanently to connect the well or other water system to the valve-controlled discharge line of an over-rim, city water supplied gravity or booster-connected tank. To avoid the installation of an extra pump, the city standby supply may be indirectly connected through an open tank or receptacle to the suction side of the well pump. With such an arrangement the difficulties in the event of a pump breakdown should not be overlooked.

In view of recent trends in municipal planning and control and developments in refrigeration and air conditioning, an expanded interest in the type of work outlined above is anticipated. New regulatory codes will undoubtedly be formulated and existing ones revised. Where applicable, it is hoped that the material here presented will prove useful.

References

1. Reichman, Irving. The Use of Water in Refrigeration and Air Conditioning. Refrigerating Engineering, **47**: 113 (1944).
2. Reichman, Irving. The Conversion Factor as an Index of Ice Plant Water Economy. Ice & Refrigeration (April, 1944).
3. American Standards Association. Air Gaps & Backflow Preventers in Plumbing Systems. ASA A40.4 (1942) A40.6 (1943).

Bank Payment of Water Bills

RECENTLY Mr. B. E. Payne, Chief Engineer and Superintendent of Louisville Water Company (Kentucky) sent to the American Water Works Association headquarters, a large advertisement in which his Company invited its customers to pay their water bills at their own banks. A letter to Mr. Payne asking for further details brought forth this reply:

"The following is some additional information on the method used here in Louisville of payment of utility bills by the customer's bank.

"Both the Louisville Water Company and the Louisville Gas & Electric Company use this method of collection for about two per cent of their revenue on approximately two per cent of their monthly bills.

"This system has been in use by the Water Company for about 8 or 10 years, and by the Gas & Electric Company since 1908. It was started by the cashier of the Louisville German Bank (now extinct) for the payment of his gas and electric bill, so that he would not miss his discount. The idea appealed to the traveling men living in Louisville. Also the banks used it as a method of encouraging checking accounts.

"The procedure is as follows:

(1) The customer fills out the attached form (*see* p. 358) and returns it to the Water Company; at the same time he notifies his bank to honor this request.

(2) The Water Company sends all bills to its own bank and receives credit on its regular account for the net amount of each bill.

(3) The bills are then handled and cleared as checks. The customer receives the stub of the bill with his cancelled checks at the end of the month.

(4) If he wishes to protest the bill he has the same rights and privileges as if he had paid it at the Company office.

Mr. Payne states that his Company finds this a splendid method, saving postage, saving handling in the water office, and aiding in collections. It enables the customer to pay his water bill without mailing a check or going to the water office. It saves him the worry of paying the bill within the discount period. The Water Company allows a discount of 33⅓ per cent, which is worth saving.

"It may interest you to know," continues Mr. Payne, "the other methods of collection and the per cent of revenue obtained through each: 2 per cent bank payments by the above method; 15 per cent sub-agencies (drug or grocery store); 30 per cent Company's office; 43 per cent by mail."

Mr. Harry E. Jordan, Secretary of the A.W.W.A., in answering Mr. Payne's letter said in part:

"I think I told you in my earlier letter that the American Bankers Association staff member with whom the

subject was discussed, was not particularly enthusiastic about the device (paying utility bills through local banks) as one to be promoted at the present time. Your letter indicates that the policy is one that has been established for several years in Louisville. We feel that the idea has some merit."

SAVE YOUR DISCOUNT AND YOURSELF TROUBLE BY PAYING YOUR BILLS THROUGH YOUR BANK

Many of our customers are taking advantage of this convenience by authorizing our Company to send their bills directly to their Bank. In this way you will always be able to save your discount and avoid the trouble of coming to the office and paying your bill, thereby helping to conserve gasoline and tires.

In case of error this does not waive any of your rights in having bill corrected.

If you wish to take advantage of this convenience, kindly fill out and sign the form below and return to the LOUISVILLE WATER CO. At the SAME TIME make arrangements with your Bank to honor same; and in the future present your bill to your Bank, and you will receive your receipted bill along with your cancelled checks.

.....

Louisville, Ky. 194

Louisville Water Co.
435 So. Third St.
Louisville, Ky.
Gentlemen:

This will be your authority to send my Water Bill or Bills to the

.....
(Name of Bank)

for Payment of the net amount thereof for services rendered to me at

..... Attachment No. .....
(Street and House Number)

The above Bank has been notified to pay bill when presented. This authority is to continue from month to month until you are notified in writing to the contrary.

After the bill is paid it is understood the receipted portion of same will be delivered to me by the Bank along with my cancelled checks.

Yours very truly,

Report of the Audit of Association Funds for the Year Ending December 31, 1943

To the Members of the American Water Works Association:

The By-Laws require that the Secretary shall have made an annual audit of the books of the Association.

The records for 1942 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Reference may be made to past audits which appeared in the JOURNAL as follows: pp. 520–25, March 1938; pp. 570–74, March 1939; pp. 516–20, March 1940; pp. 774–78, April 1941; pp. 426–30, March 1942 and pp. 338–342, March 1943.

There is also submitted a membership statement for 1943 and a comparative record for 1933–1943 inclusive.

Respectfully submitted,
HARRY E. JORDAN, *Secretary*

February 11, 1944

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1943, and the statements of income and expenses and surplus for the year then ended, have reviewed the system of internal control and the accounting procedures of the Association and, without making a detailed audit of the transactions, have examined or tested accounting records of the Association and other supporting evidence, by methods and to the extent we deemed appropriate. Our examination was made in accordance with generally accepted auditing standards applicable in the circumstances and included all procedures which we considered necessary.

In our opinion, the accompanying balance sheet and related statements of income and expenses and surplus present fairly the position of the American Water Works Association at December 31, 1943, and the results of its operations for the year, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)
LOUIS D. BLUM & Co.
Certified Public Accountants

EXHIBIT A—Balance Sheet, December 31, 1943

Assets

Cash in Banks and on Hand		$25,849.52*
Accounts Receivable:		
Advertising	$3,156.00	
American Public Health Association	1,430.67	
Advances—Committee on Water and Sewage Works Development	2,702.44	
Reprints	81.29	
Other	174.00	7,544.40
Membership Dues		146.75
Accrued Interest on Bonds		371.14
Inventories:		
Paper stock	$1,236.23	
Type metal	351.33	
Manual of Water Quality and Treatment (513 copies)	318.06	
Cumulative Index (356 copies)	427.20	
Manual of Water Works Accounting (19 copies)	27.55	
Sundry publications	505.80	
Membership certificates	5.62	
Fuller Memorial Award certificates	34.51	
Back issues—Journals—Vols. 1 to 35, inclusive (28,765 copies)	—†	
Back issues—Proceedings—1881 to 1926 inclusive (306 copies)	—†	2,906.30
Office Equipment: (Less depreciation)		3,914.78
Investments at Cost, including excess of redemption value of United States Savings Bonds over issue price—(Quoted value December 31, 1943, $68,174.75) Per Schedule 1		69,971.36
1944 Convention Expense		149.99
Total Assets		$110,854.24

Liabilities and Surplus

Accounts Payable	$440.19
Taxes Withheld—Employees Salaries	1,605.90
Membership Dues—Advance Payments	12,828.74
Unearned Subscriptions to Journal	1,600.05
Reserve for Award Fund (McCord)	4.56
Reserve for Expenses of Carbon Research Committee	48.46
Surplus, per Exhibit "C"	94,326.34*
Total Liabilities and Surplus	$110,854.24

* Canadian funds in the Bank of Montreal as at December 31, 1943 amounted to $1626.95 which, if converted into U. S. currency at that date, would have resulted in a loss of approximately $168.80. Had this loss been recorded, the cash in banks and the surplus would have been decreased accordingly.

† Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the years of publication.

EXHIBIT A, SCHEDULE 1—INVESTMENTS—BONDS, DECEMBER 31, 1943

Description	Interest Rate %	Principal Amount	Cost	Quoted Market Value 12/31/1943
City of Los Angeles	3½	$2,000.00	$2,241.11	$2,390.00
International Telephone and Telegraph Co.	5	3,000.00	2,895.00	2,463.75
Southern Pacific Railroad Co.	4½	5,000.00	4,875.00	3,450.00
Province of British Columbia	4½	1,000.00	1,000.00	1,085.00
Province of Ontario	4½	2,000.00	1,690.00	2,110.00
Province of Ontario	4	1,000.00	732.50	1,105.00
Canadian Victory Bonds	3	6,000.00	5,647.75	5,385.00
Canadian Victory Bonds	1¾	2,000.00	2,000.00	1,780.00
United States Certificate of Indebtedness—Series B	⅞	1,000.00	1,000.00	1,000.00
United States Savings Bonds—Series C	2.9*	7,000.00	5,250.00	6,090.00†
United States Savings Bonds—Series C	2.9*	10,000.00	7,500.00	8,400.00†
United States Savings Bonds—Series D	2.9*	10,000.00	7,500.00	8,300.00†
United States Savings Bonds—Series D	2.9*	10,000.00	7,500.00	8,100.00†
United States Savings Bonds—Defense Series G	2½	10,000.00	10,000.00	9,620.00†
United States Savings Bonds—Defense Series G	2½	2,000.00	2,000.00	1,956.00†
United States War Savings Bonds—Series G	2½	5,000.00	5,000.00	4,940.00†
Excess of redemption value of U. S. Savings Bonds—Series C and D over issue price			3,140.00	
			$69,971.36	$68,174.75

* Yield if held to maturity.
† Current redemption value.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES FOR THE YEAR ENDED DECEMBER 31, 1943

Operating Income:		
Annual dues	$48,255.70	
Advertising	30,660.53	
Subscriptions to Journal	2,986.54	
Conference registration fees	4,729.79	
Conference—Other events	213.49	
Water and Sewage Works Mfrs. Association	7,500.00	
Interest on Investments*	1,951.34	
John M. Goodell prize	75.00	
Miscellaneous interest income	11.56	
Total Operating Income		$96,383.95
Publication Income:		
Manual of Water Quality and Treatment	$1,374.89	
Manual of Water Works Accounting	158.00	
Reprints	1,531.40	
Cumulative Index	52.75	
Membership certificates	53.60	
Proceedings and Journals	906.28	
One-half of profits from sales of Standard Methods of Water Analysis	1,430.67	
Specifications:		
Miscellaneous	233.75	
Meters	57.43	
Cast iron pipe	473.20	
Steel pipe	55.63	
Elevated steel tanks	320.07	
Repainting tanks	104.45	
Gate valves	137.94	
Fire hydrants	85.40	
Sluice gates	3.75	
Water Conservation	908.53	
Total Publication Income		7,887.74
Total Income (carried forward)		$104,271.69

* This account includes $740.00 which represents the increment in redemption value on United States Savings Bonds for the year 1943.

Total Income (brought forward)			$104,271.6
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$3,229.63		
Stenographic expense	204.50	$3,434.13	
Administrative Expenses:			
Rent	$3,348.42		
Office supplies and services	4,823.55		
Membership promotion	207.63		
General travel expense	55.94		
Legal and auditing expense	894.17		
Corporation fees	108.00	9,437.71	
Administrative Salaries:		33,550.92	
Committee Expense		645.27	
Division and Section Expense:			
Division expense	$30.68		
Section—membership allotment	4,904.87		
Section—official travel	1,838.39		
Section—general expense	205.29	6,979.23	
Journal:			
Printing	$18,630.56		
Paper	3,731.82		
Abstractors	577.13		
Storage—Journal paper stock	129.48	23,068.99	
Conference:			
General	1,424.28		
Entertainment	3,080.85		
Management Committee	117.92		
Publicity	663.84	5,286.89	
Membership Dues in Other Associations		575.00	
John M. Goodell Prize		75.00	
Fuller Memorial Award		8.62	
Depreciation of Office Equipment		537.20	
Moving Expenses		638.82	
Miscellaneous Expense		247.98	
Total Operating Expenses		$84,485.76	
Cost of Publications Sold:			
Manual of Water Quality and Treatment	$401.26		
Manual of Water Works Accounting	65.24		
Reprints	1,267.55		
Cumulative Index	37.70		
History of Water Purification	1,605.58		
Membership certificates, including lettering and mailing	56.33		
Journals and Proceedings	8.47		
Specifications:			
Miscellaneous	81.62		
Meters	54.76		
Cast iron pipe	297.17		
Steel pipe	38.23		
Elevated steel tanks	329.38		
Repainting tanks	49.45		
Gate valves	93.41		
Fire hydrants	76.09		
Sluice gates	1.05		
Water Conservation	2,600.35		
Total Cost of Publications Sold		$7,063.64	
Development Expenses—Research:			
Depreciation—water works structures	$414.87		
Wartime activities	1,870.86		
Water and sewage development	1,660.15		
Total Development Expenses		3,945.88	
Total Expenses			$95,495.2
Net Income for the Year (Transferred to Exhibit "C")			$8,776.4

EXHIBIT C—SURPLUS ACCOUNT FOR THE YEAR ENDED DECEMBER 31, 1943

Balance, January 1, 1943	$85,549.93
Add: Net income for the year, per Exhibit "B"	8,776.41
Balance, December 31, 1943, Per Exhibit "A"	$94,326.34

Membership Statement—Year of 1943

	Active	Corporate	Associate	Honorary	Junior	Affiliate	Total
Total Members, January 1, 1943	3695	390	219	29	20	88	4441
Changes in Membership Grades	4	—	—	4	5—	3—	—
	3699	390	219	33	15	85	4441
Gains:							
New Members During 1943	678	59	20	—	4	8	769
Reinstated During 1943	81	3	2	—	—	2	88
	4458	452	241	33	19	95	5298
Losses:							
Resignations and Deaths	117	6	1	4	—	2	130
Dropped for Non-Payment	178	4	2	—	—	14	198
Total Members, December 31, 1943	4163	442	238	29	19	79	4970
Total Members, January 1, 1943	3695	390	219	29	20	88	4441
Gain in Year of 1943	468	52	19	—	1—	9—	529

Comparative Statement—Gains and Losses—Sixteen Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Non-Payment of Dues	Gain or Loss	Total Members at End of Year
1928	203	36	99	126	+14	2456
1929	314	25	118	130	+91	2547
1930	501	39	122	134	+285	2831
1931	203	22	123	216	−114	2717
1932	117	22	169	297	−327	2390
1933	168	56	159	234	−169	2221
1934	271	66	86	122	+129	2350
1935	565	42	85	190	+332	2682
1936	311	53	104	218	+42	2724
1937	515	86	122	139	+340	3064
1938	520	59	144	140	+295	3359
1939	578	64	112	179	+351	3710
1940	514	58	113	212	+247	3957
1941	480	92	116	236	+220	4177
1942	570	59	132	233	+264	4441
1943	769	88	130	198	+529	4970

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

WARTIME WATER WORKS PROBLEMS

Some Problems of Water Supply for Troops. JACK J. HINMAN JR. Military Engr. **35:** 560 (Nov. '43). Quant. and qual. of water supply remain first considerations for troops. Min. necessary quant. varies with locality, humidity, temp. and effort required of men. Under certain conditions man may exist on 1 qt. per day temporarily. Usual min. in test, ½ gpd. per man. Common value for computing need at temporary camp, 5 gpd. per man. Consumption ranges upward as facilities permit. Car requirements range from qt. to several gal. according to weather, car type and work done. Animals used-5–10 gal. each. Water delivery from source by tank trucks, carts, trailers, semi-trailers, tank cars and pipelines. Little consumed at source. 5-gal. quant. for 1 man weighs 42 lb., occupies 1155 cu.in. Qual. considerations same as for civilian use: free from dangerous bacteria, parasitic protozoa, worms, etc., or as nearly safe as possible; free from poisonous substances in amt. causing physiol. effect whether by enemy contamn., exposure to chem. warfare agents, or introduced at source or in handling; as attractive in taste, temp., color, clarity as possible; and as free as possible from corrosive, scaling or other equip. damaging properties. When necessary, safety comes first, attractiveness second. Problem of secondary contamn. during haulage and handling apt to be serious but commonly combated by using chloramines and raising Cl_2 residual to meet such secondary Cl_2 demands. To secure acceptable water qual. site selection first consideration, detd. by existing and potential poln. sources; quant., depth and availability of ground water when such information available; accessibility by water carriers; unobstructive to traps or traffic; and protected from enemy observation. After site selected, water purif. equip. brought forward and set up by engrs. Water lifted by self-priming centrifugal pump, chlorinated, treated with alum and filtered. If turbid, 3000-gal. portable canvas tanks as sedimentation basins set up to reduce mud-load on filter. Filtered water delivered into such canvas tank and chlorinated to give 1 ppm. Cl_2 at point of consumption. Where heavy chlorination necessary, subsequently dechlorinated with Na thiosulfate or Na sulfite. Elevated wooden and steel towers to support canvas storage tanks undesirable and gravity flow therefrom slow. In lieu, tanks set on carefully smoothed ground or plank flooring. Small, gasoline-driven self-priming centrifugal pumps lift water from tanks to carrying equip. and act as booster pumps about installation. Water properties and treatment hazards vary widely, constituting serious problems. Ordinary treatment chiefly with portable purif. unit, '40 model; light, 2-part unit easily handled by manpower and commonly carried on truck or trailer. Issued and accompanied by canvas tanks, booster pumps, base and necessary fittings. Also larger unit, Mobile Water Purif. Unit, M-III, truck-mounted filter plant of 90 gpm. capac. Lab. equip. principally illuminated comparator for detg. free Cl_2 and pH. Both units depend upon alum for coagulation and upon fused $NaCO_3$ for pH adjustment. Mobile unit uses liq. Cl_2 for sterilization while portable units use high-test hypochlorites.—*Ralph E. Noble.*

Sea Water for Drinking. ANON. Wtr. & Wtr. Eng. (Br.) **46:** 343 (Aug. '43). Three types of still produced—one by Dept. Sci. & Indus. Research, another under auspices of Admiralty, and third commercially in collaboration with Ministry of War Transport. Last method mentioned in production and capable of producing ½ gal. of fresh water for each hour worked. Still can be worked with either solid fuel or paraffin. Little information about another type devised in U. S.—*H. E. Babbitt.*

Water Supply in North Africa. WILLIAM J. DIAMOND. Military Engr. **35:** 565 (Nov. '43). Wells of all types principal water sources in N. Africa each requiring deep-well turbine pumps. Water then forced through hypochlorinator or spilled into tank and picked up by portable or mobile unit. If well less than 40′, platform made 15′ above water surface to support auxiliary pump for pushing water up to ground surface and suction of above named units. In Tunisia and Fr. Morocco numerous deep dug and shallow dug wells. Possible to pump from latter with portable or mobile units. In Tunisia particularly, many wells contamd. by feces, garbage, animal carcasses and trash. One showed 5000 bacteria per ml. after Cl_2 treatment. Better to seek new well. Majority of wells in Algeria and Fr. Morocco high in saline. Total mineral content causing hardness also high, often several thousand ppm. In Tunisia, water remarkably soft but with small saline content. Drilled wells negligible when Americans arrived but many since drilled by engrs. Some abundant producers, others failed or gave unfit water. Satisfactory ones worked by deep-well turbine pumps. Streams play small part in N. Africa because larger ones dry except during rainy season and all contamd. to variable deg. except those remote from habitation. Stream contamn. by natives, flocks and herds unpreventable. Springs fairly common in Tunisia, some sections of Algeria and Fr. Morocco. Many can be developed into good supply sources by cutting galleries into rock strata and diverting all small flows into 1 collecting basin for units to lift and process. Spring water qual. satisfactory when not used by Arabs. Easily cleaned and kept in good condition by imposing san. regulations on latter. Water from all sources except streams remarkably clear, requiring no filtration. Chlorination by gas with mobile units or solid Ca hypochlorite with portable unit and hypochlorinator. $CuSO_4$ used in small quants. against algae in spring collecting basins. Alum and soda ash used with filtration in purif. of streams. During Tunisian campaign, water points moved forward as troops advanced and conversely. Installations, therefore, temporary and little or no pipe and lumber used. Later, elaborate installations made. 14′ platforms freed auxillary pumps for other use, proving efficient and satisfactory. Difficulties met in N. African operations: (1) motor maint. of Production Platoon; (2) maintg. communication with water points extending 50–100 mi. from headquarters; and (3) securing personnel to operate more water points than planned by Tables of Organization. First solved by designating 2 men from Installation Sec. as Platoon Headquarters mechanics. They serviced motors at site and completely overhauled each unit and motor monthly. Second, by placing 1 purif. sgt. in charge of all purif. personnel, with main task of visiting each water point every other day, collecting daily reports, delivering materials, rations, gas, etc., and checking operations. Last, by operating under revised Tables of Organization. Installation Sec. reduced to 1 sgt., 1 cpl., 3 carpenters, and 2 pipe-fitters. Remainder of sec. placed in Purif. Sec., thus providing 24 men to operate 8 points with 3 men each.—*Ralph E. Noble.*

The Necessity of Living Off Each Others Inventories. JAMES H. COLLINS. Pub. Util. Fort. **32:** 210 (Aug. 19, '43). WPB set-up in Los Angeles and Portland for pooling excess inventory stock of water, elec. and gas utils. of western states deemed successful. Postwar prediction by some utility men that "inventory fat" will be discontinued. All utils. in dist. considered this necessary war measure and co-operated to fullest extent. Utils. reported surplus stock to central inventory office. Utils. which need materials then state wants to central office which in turn furnishes list of such material together with name and address of nearest owners. Applicant carries on bargaining direct with owner, and notifies central office of all material purchased so that it may be cancelled from inventory. Pool available to utilities only, with exception of private contractors building camps, barracks and other military plants. Simplification and standardization of materials and equip. important in order for interchange of inventories to be successful.—*H. J. Chapton.*

PUMPS AND PUMPING

Do's and Don'ts on Pump Operation. F. J. HILL. N.D. Water and Sew. Works Conf. Bul. **10:** 12: 4 (June '43). Important and patriotic duty to care for pumping equip. properly and save much needed metals for war effort. *Installation:* Follow mfr's. directions precisely. *Oiling or water lubrication:* Use proper oil and amt. recommended by maker; neither over- or under-lubricate. Over-lubrication carries grit and dirt into vital bearings. Clean oilers, reservoirs and grease cups frequently. Never use dirty oil can or grease gun; clean spout well before discharging. Meantime, store cans and guns in well-made, tight cupboard beyond range of winds and dust-laden air. Avoid combustion danger by not leaving oil-soaked waste or rags there. Use good qual. lubricants as cheap oils and grease expensive in long run. *Motors:* check motor for cleanliness throughout. Delicate and high-speed bearings make lubrication with proper amt. of right oil important, particularly in case of reservoir type bearing where tolerances very close. *Controls:* Be sure properly operating, particularly *overload* release in magnetic starters as insurance against burnout. Keep contacts in proper condition and arc-free. Keep motor in perfect alignment with driven unit, watching for settling of concrete bases. Investigate cause of unusual noise. Keep commutator clean and smooth, dressing it with care only if necessary and with knowledge how. *Maintenance:* First comes cleanliness, then lubrication and careful attention to actual operation. Most important is perfect alignment from bowl to thrust bearing to avoid broken shafts and damaged bearings. Check foundations frequently for settling. If oil-lubricated type, use proper kind of castor oil required for water well purpose. If water and pre-lubrication required allow water to soak bearings before starting motor. With drip method, allow sufficient drip and keep free from stoppage by corrosion. Make impeller adjustments according to mfgr's. instructions. Where reservoir type of lubrication involved, drain and wash reservoirs semi-annually, replacing oil with clean fresh motor oil. *Horizontal centrifugal pumps.* Troubles: (1) Priming. Proper priming absolute necessity. Fill suction pipe to point above top of pump casing and exhaust air from latter through petcock. May use auxiliary pumping unit to exhaust pump and suction pipe. (2) No water delivered. Pump not primed; speed too low; discharge head too high for pump; suction lift too high (over 15′); impeller completely plugged with debris or corrosion; or pump driven in wrong direction. (3) Not enough water being delivered. In addition to items under (2), cause may be air leaks in suction piping; wearing rings worn; damaged impeller; improper casing gaskets allowing air leakage; foot valve too small; or suction pipe not deep enough. (4) Not enough pressure. Speed too low; air in water; mech. wear as above; impeller diam. too small; loose gland admitting air. (5) Pump works a while then loses suction. Leaky suction line; water seal plugged; suction lift too high (over 15′); or loose glands. (6) Pump takes too much power. Speed too high; head lower than rating—pumps too much water; bent shaft; rotating element binds; stuffing boxes too tight; wearing rings worn; or improper casing gaskets.—*Ralph E. Noble.*

Conservation of Centrifugal Pumps. B. L. CODY. Chem. & Eng. News **21:** 2103 (Dec. 25, '43). All pumps requiring similar maint. should be grouped together in maint. index classified in accordance with: (1) operating hours per month; (2) deposits and condensation on pump parts; (3) liquid handled; and (4) deg. of inspection incident to routine operation. Under favorable conditions for well-selected and well-cared-for pumps general maint. schedule may follow time table. Every month: (1) check bearing temp. *with thermometer* (hot bearings indicate need for change in amt. or grade of lubricant); (2) check on oil grooves and alignment of drive. Every 3 mo: (1) drain and flush out lubricant; (2) check freedom of oil rings to rotate; (3) measure clearances in sleeve bearings. Every 6 mo: (1) repack if necessary; (2) check alignment; (3) exam. for pipe strains by disconnecting and noting whether pump springs in either direction; (4) check piping supports for adequacy. Every year dismantle completely and inspect every part including: (1) shaft sleeve for grooving; (2) wearing rings for diametrical clearances which should not exceed 0.020–0.030″; (3) ball bearings for defects; (4) sleeve bearings for wiped areas where lubricant failed; (5)

stuffing box for stiff or misshapened rings; (6) casing and runner cleaned; and (7) auxiliary fittings inspected. If replacement gasket required on reassembling casing, new gasket should match thickness of old within 0.001" and be cut to fit well without damaging. Gasket should extend into stuffing box. Grease packing rings before insertion, compress into place with metal ring and screw gland plate nut finger tight behind last ring. Run intermittently, 2 min. at a time, until stuffing box tightness relieved. Allow little leakage from gland. Extra capac. obtainable by chipping back under side of outlet vane tip to taper to thin section, increasing diam. of belt drive pulley, or reducing head loss in discharge piping. Suction line should be one size larger than pump suction nozzle and connected by eccentric reducer. Air pockets cause loss of prime, seizing in wearing ring fits, interstage bushings or in stuffing box, and loss in flow. Flashing due to hot liquids has same effect as air binding.—*A. A. Hirsch.*

The Wartime Care of Centrifugal Pumps. H. D. JOHNSON. Internatl. Engr. **84:** 69 (Sept. '43). Following taken from table showing cause and cure of pump trouble: *No water delivered:* (1) Lack of prime. Fill pump and suction pipe *completely* with water. (2) Speed too slow. Check whether motor directly across-the-line and receiving full voltage. Frequently may be too low; motor may have open phase. Correct. (3) Discharge head too high. Check pipe-friction losses. Larger piping may elim. condition. See if valves wide open. (4) Suction lift too high. If no inlet obstruction, check for pipe-friction losses. *Static* lift may be too great, however. Measure with mercury column or gage while pump operates. If too high, water to be pumped must be raised, or pump lowered. (5) Impeller completely plugged. Remove pump casing top and clean impeller. (6) Wrong direction of rotation. Compare turning motor with directional arrow on pump casing. *Not enough water delivered:* (7) Air leaks in suction piping. If liq. pumped water or non-explosive, and explosive dust or gas absent, test flanges for leakage with flame. For liqs. such as gasoline, test suction line by shutting or plugging inlet, putting line under pressure. Seal leaks. (8) Air leaks in stuffing box. Check for thin water stream from stuffing box while pump working. If none, and flow not produced by reasonable gland adjustment, probably new packing needed. Water-seal piping may be plugged and need cleaning. Lantern ring may be displaced and need centering at water-seal piping. (9) Speed too slow. *See* (2). (10) Discharge head too high. *See* (3). (11) Suction lift too high. *See* (4). (12) Impeller *partially* plugged. *See* (5). (13) Not enough pos. suction head for hot water. (Det. with gage. If water flashing into steam, gage fluctuates widely.) Pump may need placing considerably lower than hot-water source to permit flow in under pressure. Consult pump mfr. (14) Defective wearing rings. Inspect and replace if worn excessively. (15) Defective impeller. Inspect and replace if damaged or blade sections badly eroded. (16) Defective packing. Replace packing, also sleeves if very worn. (17) Foot valve too small or partially obstructed. Inspect. Area through valve ports should be as large as area of suction pipes, preferably 1½ times. If strainer used, net clear area should be 3 to 4 times that of suction pipe. (18) Suction inlet not immersed deep enough. If inlet not lowerable, or if swirling eddies through which air sucked persist when lowered, chain board to suction pipe. Latter drawn into eddies, smothering vortex. (19) Rotating in wrong direction. Symptoms, over-loaded drive and about ½ rated capac. from pump. *See* (6). *Not enough pressure:* (20) Speed too slow. *See* (2). (21) Air or gases in liq., e.g., marsh gas in swamp water. (Test in lab., reducing pressure on liq. to pressure in suction line. Watch for bubbling.) May be possible to operate pump to provide adequate pressure despite condition. Better to provide gas separation chamber on suction line nera pump, periodically exhausting accumulated gas. (22) Mech. defects. *See* (14), (15), (16). (23) Too small impeller drain (probable cause if none, of above). Consult pump mfr. to det. whether larger impeller practical. Otherwise, cut pipe losses, or increase speed, or both. *Be careful not to overload drive seriously. Pump works a while and quits:* (24) Incomplete priming. Free pump, piping and valves of *all* air. Prevent high points in suction line by relaying pipe if necessary. (25), (26), (27), (28) Suction lift too high, air leaks in suction piping, in stuffing box, air or gases in liq. *See* (4), (7), (8), (21). *Pump takes too much power:* (29) Head lower than rating; pumps too much water. Turn down impeller's od. in amt. advised by pump mfr. (30) Liq. heavier in viscosity or sp.gr. than

allowed for. Use larger motor. (31) Rotating wrong direction. *See* (19). (32) Stuffing boxes too tight. Release gland pressure. Tighten reasonably. If sealing water does not flow while pump operates, replace packing. If latter wearing too quickly, replace scored shaft sleeves and keep water seeping for lubrication. (33) Casing distorted by excessive strains from suction or discharge piping. Check alignment. Exam. pump for friction between impeller and casing, worn wearing rings. Replace damaged parts. (34) Misalignment. Realign pump and motor.—*Ralph E. Noble.*

How to Prevent Water System Freeze-Ups. ANON. Domestic Eng. **160:** 6: 62 (Dec. '42). First, drain all pumps and water systems not housed in frostproof shelters or protected, by design, against freezing. To drain shallow well pumps: (1) Keep all drain plugs open until pump returned to operation. Plunger types may have drain plugs for both suction and discharge valve chambers. Others may have drain vents for air charger, air chamber or unloader valve. (2) If water drains or siphons back to pump, disconnect pipeline. (3) If plunger type, run pump short interval after removing drain plugs to release any water entrapped. (4) When returning pump to service, replace all drain plugs tightly. Extreme low temps. may cause great damage unless precautions taken, including: (1) addnl. insulation, such as corn fodder over well pit or basement window; (2) introduced heat as from high wattage lamp or oil burner in well pit; (3) maintg. circulation as by keeping outlet partially open. If water service discontinued throughout winter, drain pressure tank as well as suction and discharge lines. Tank may not drain properly unless plug in top opened. If no opening in tank bottom, either pump out water or upset tank. Suction line with foot valve will not drain. Necessary, therefore, to disconnect at well. With deep well hand and windmill type pump, having cylinder down in well, inspect drain vent for possible rusting opening. Often, small hole in drop pipe below frost line drilled by mfr. for drain vent. Other deep-well hand and power pumps rendered frostproof by underground discharge connection to prevent water standing above frost line. This type also has small drain hole 4′ below platform. For power-driven units, waterproof shelter should be provided.—*Ralph E. Noble.*

Lubrication of Machinery in Water and Sewage Treatment Plants. ANON. Pub. Wks. **74:** 6: 21; 7: 23 (June, July '43). General basic principle for use of lubricants same for all mchy.; details of application vary with kinds of mchy. and operating conditions. Water and sewage plant equip. usually of low hp., generally operated by elec. motors, stationary and not subject to deposits of mud, dust, cement, rain and hard usage. On other hand, much of it operates under water which may be more or less acid or alk.; most of it in continuous presence of moisture and may be located where temp. below freezing for long periods. Mfrs. of lubricants have specified types for various uses and equip. Many of these listed and several tables given. As important as selection of proper lubricant is intelligent and faithful use in accordance with mfrs'. instructions. Equip. standing idle, e.g., between time of erection and starting of plant, requires special care to prevent any rust formation. Rust in a bearing may cause it to fail within short time. Oil should be examd. at regular periods to be sure no moisture gets into it. Overgreasing can cause trouble, as on places where ball bearings protected by oil seals. In such places, unless care used, over-greasing may force oil-seal out of place.—*Martin E. Flentje.*

Streamline Flow in Impellers and Guide Vanes of Centrifugal Pumps. FRANCIS H. STEERS. Wtr. & Wtr. Eng. (Br.) **46:** 183 (May '43). In multi-stage pump first stage least efficient. In succeeding stages reversing channel used connecting to entry of succeeding impeller eye and losses smaller. Reference made only to moving water losses. Losses due to friction and other causes ignored. Losses due to: (1) rotation of water in suction and impeller entry; (2) eddies set up by badly designed short-circuit spaces; (3) entry of vanes not being of correct hydr. width; (4) rough surfaces, lumps and incorrect shape of vanes at entry; (5) incorrect profile shape of impeller; (6) phenomenon of rotating water caused by indifferent curvatures of vanes; (7) too short channels between vanes; (8) too small ratio of inner and outer diam.; (9) differences of pressure across exit of impeller in both planes; (10) clearance space between impeller, periphery and guide vanes; (11) shock losses due to variation of exit velocs. at periphery of impeller; and (12) losses due to variation of cross-sectional

area between guide vanes and impeller vanes. Considerable evidence that water on its way through impeller does not behave in accordance with simple theory. "Pitting" and corrosion on backs of vanes require much explaining if ordinary theory of flow holds good. One great difficulty is to det. actual outlet conditions. Principal cause of departure from perfect values in ordinary pump with limited no. of vanes is impossibility of guiding every water particle in perfect course. Whirl seen to increase continuously from back of one vane to front of next. There exists in guide passages and within impeller alternating veloc. imposed on normal flow. Total head given by pump is sum of increase due to centrifugal force and conversion of veloc. with which water leaves impeller. Internal design of all impellers governed by entrance or inlet angle of vane and delivery or exit angle of vane. Eff. of pump is function of these angles. Water will not enter eye of impeller all round in straight single inlet branch unless stationary direction vanes used. Straight cones more efficient diffusers than certain trumpet-shaped pipes; well-defined "best" angle of dilation for each particular fluid, or material of wall, etc.; deg. of polish given to walls of diffuser not of paramount importance; and just as harmful to its eff. to have diffuser opening out too quickly as to make it too slender. One of most efficient diffusers consisted of 8 diffuser nozzles starting with rectangular section near impeller periphery and then being shaped into cone of circular cross-section, enlarging at bend for streamlines to follow ideal fluid path, and reducing again to circular section for next impeller supply. As impeller vanes constantly moving past guide vanes, const. change of clear guide channel cross-section. Impeller reaches point where position of vanes between surrounding guide vanes and guide channel area decreased by impeller blades. For this reason usual to sharpen impeller vanes at exit. Veloc. from impeller periphery in changing to veloc. in casing must choose its own path and meet body of water in circular motion in casing. Expts. show that under same conditions apparently no great difference between spiral and circular casings as assumed. Tests show head of impending delivery greater with spiral casing than with circular casing by about 5% of head at impending delivery. For circular casing pressure in discharge chamber practically const. all round and tests show that power required greater with spiral case than with circular casing in some instances. When guide vanes used in conjunction with spiral casing, they do not act in efficient manner, as friction set up outweighs their advantage and most of conversion carried out in spiral casing.—*H. E. Babbitt.*

Centrifugal Pump Performance as a Function of Specific Speed. A. J. STEPANOFF. Trans. A.S.M.E. **65:** 629 (Aug. '43). Leakage loss in centrifugal pump can take place: (1) between 2 adjacent stages in multi-stage centrifugal pumps; (2) between casing and impeller at impeller eye; (3) at stuffing box; (4) through balancing devices; (5) at bleed-off from stuffing box through close-fitted bushing to reduce pressure on packed stuffing box; (6) past vanes and casing in open impeller pumps; and (7) any water used for bearing and stuffing-box cooling. Leakage loss rapidly decreasing with increasing specific speed. Power loss due to leakage const. for pumps of same specific speed, irrespective of pump size and speed. Variation of mech. eff. (e_m) mostly affected by disk-friction loss, which varies greatly with specific speed, while remaining mech. losses, i.e., bearing and stuffing-box friction, essentially independent of specific speed. Disk-friction loss increases with clearance between disk and stationary wall 4%; painting of rough c-i. casing reduces disk-friction loss 16–20%; polishing disk reduces loss 13–20%; badly rusted c-i. casing walls increase disk-friction loss 30% as compared with clean bronze casing. Little actual data available on value of mech. losses. For purposes of this paper, stuffing-box and bearing friction loss assumed at 2% and independent of specific speed. Optimum gross eff. of centrifugal pumps varies with specific speed, reaching max. at specific speeds of 2000 to 3000 for double-suction pumps. Friction coefs. for calcn. of flow through annular clearances independent of length of throttling surfaces, their diam. and clearance. Study of losses at partial capacs. at const. speed reveals existence of "circulation" losses. This is loss of power caused by relative internal circulation within impeller channels and also from channel to channel. Loss zero near best eff. point and max. at zero capac. Loss greater with high-specific-speed pumps. *Discussion.* J. W. DAILY: Head-capac. curve for idealized flow indicated by author divorced from phys-

ical facts. Theoretical equation for head:

$$h = \frac{V_2 Cu_2 - V_1 Cu_1}{g} = \frac{V_2 C_2 \cos \alpha_2 - V_1 C_1 \cos \alpha_1}{g}$$

where h = head, V = tangential veloc. of impeller, and $Cu = C \cos \alpha$ is tangential component of abs. veloc. of flow, merely expression of theorem that rate of change of angular momentum which fluid undergoes as it passes through machine proportional to torque applied. Can be used for any pump if true values of velocs. and angles inserted. Starting point for evaln. of losses in centrifugal pump can well be torque curve, after elimn. of mech. and disk-friction losses. O. H. DORER: Disputed that bearing and stuffing-box loss as high as given. Using author's hydr. eff. and disk-hp. detn. results in much less head loss and much higher net eff. than known to be obtained on oils. Necessary to check performance on viscous fluids to develop facts as to relative losses caused by disk friction, leakage and stuffing-box loss. KARL EKLUND: Main difficulty to use of specific speed (N_s), speed factor ϕ, and all other definitions to tech. practice, such as unit speed and unit discharge, is that relations expressing these functions hold between 2 machines only at same eff. and only if influence of Reynolds no. neglected. R. G. FOLSOM: For satisfactory correlation of coefs. on basis of Reynolds no., some consideration of influence of rotating wearing ring must come into basic equation. Comparing exptl. values of f with usual pipe-friction values found that author's values in order of twice normal pipe exptl. coefs. I. J. KARASSIK: When dealing with water procedure, in detg. mech. eff., combining stuffing-box and bearing losses into single term more erroneous than dangerous. If, however, viscosity taken into consideration fallacy of multiplying mech. losses by viscosity correction factor obvious. Suggested that mech. eff. of centrifugal pump be henceforth defined as:

$$\eta_m = \frac{P_b - P_m}{P_b}$$

in which η_m = mech. eff.; P_b = brake hp.; and P_m = mech. hp. R. T. KNAPP: General value of some equations in paper lessened by use of non-consistent series of dimensions or by non-std. definitions of well-accepted terms. Only first half of author's statement correct in which he says that leakage loss greater for smaller pumps as clearances cannot be reduced below certain min.; also because wearing rings of larger pumps wider and coef. of discharge smaller. Large fraction of significant progress in centrifugal pump and turbine design in future is to come as result of carefully controlled exptl. lab. investigations. C. R. MOCKRIDGE: Stuffing-box friction loss relatively small in large pumps. Frictional hp. absorbed in stuffing boxes in cold water service depends upon following: packing, finish, concentricity and material of shaft sleeve; length of stuffing box; rpm. of shaft sleeve; fluid pressure sealed against and leakage from stuffing box. ARVID PETERSON: Method described for detg. hydr. eff. used for many years by pump designers. Power required for pump at partial capacs. and const. speed less for lower specific-speed pump than for one of higher specific speed. While true that optimum gross eff. of centrifugal pumps varies with specific speed, equally true that, at definite specific speeds, gross eff. varies with total head—fact not clearly brought out in paper. A. F. SHERZER: Expressing eff. of centrifugal pumps as function of specific speed not entirely logical and leads to some misunderstanding. Pumps can have same specific speed and differ widely in eff. Author attempts to prove that power loss due to leakage const. for pumps of equal specific speed, irrespective of pump size and speed. Ridiculous and contrary to fact. *Author's Closure:* Paper intended as aid in calcn. of leakage for centrifugal pumps and units adopted those used in commercial design. Further refinements in presentation of test results may be justified when more and better data available.—*H. E. Babbitt.*

Pumping Station Construction at Western Air Fields. A. J. TAUNTON. Can. Engr.—Wtr. & Sew. **81:** 9: 15 (Sept. '43). General design details of water supply systems of No. 2 Training Command of Joint Air Training Plan, which includes some 34 stations. Pop. of avg. school 1400. One establishment houses 2500. In some cases supply from municipalities, but in majority from developed aquifers. Latter often very hard; softening plant being installed at one and contemplated at others. Most wells 50′ or less deep and consist of outer casing with inner casing terminating in perforated bronze screen resting on concrete or wooden plug, many including prepd. gravel wall. Well pumps mostly of vertical turbine type, elec-

trically driven and fitted with power take-off in case of power failure. Operation is by remote control from water level in storage tanks or pressure in pipeline. Heating of well pumps to prevent freezing effected by small elec. coil or strip heater. Daily consumption as high as 80,000 gal., avg. per capita use about 50 and max. avg. 56.7 gal., with 4 peak periods daily. Storage requirements progressively increased from 50,000 to 200,000 gal. Service pumps, of single-stage volute type, double suction, direct-connected to elec. motors, have capac. of 130 gpm. at 50 psi. Operate intermittently, about 1 min. in 4 or 5, in conjunction with pressure tanks in upper floors of pump houses and are controlled by pressure switches. Early tanks had 2000-gal. capac.; now three 600-gal. tanks used. Air compressors, electrically driven, of 2-cfm. capac. Munic. supplies chlorinated at source, others prior to entry to pressure tanks using hypochlorinators and maintg. residual of 0.1–0.2 ppm. Major mobile fire-fighting units consist of pumper fire trucks, rated at 600 gpm., with 120-psi. pump pressure and 10′ suction lift. Trucks carry 80-gal. water tanks and have three 2½″ outlets. Fixed equip. consists of 600–1000-gpm. fire pumps which boost pressure to 90 psi. when alarm given. For 135–150-psi. pressure required for fog nozzles fire-truck pumper connected to hydrant. Using 1″ tip, good fire stream will deliver 190 gpm. Owing to overloading of elec. power systems, gasoline engines, formerly used for standby, now primary motive power for fire pumps. Pump houses are heated by electric immersion heaters in hot water radiators.—*R. E. Thompson.*

CORROSION AND CORROSION CONTROL

Prevention of Corrosion in Hot-Water Plants. G. SEELMEYER. Z. Ver. Dtsch. Ing. (Ger.) **85:** 859 ('41). Corrosion in hot-water plants prevented if continuous protective layer maintd. over surface of metal. Formation of such film affected by concn. of D.O., hardness of water, CO_2 equilibrium, rate of flow of water and presence of small quants. of compds. of chlorine or sulfur. Protective layer on iron or steel formed only when water contains at least 6 mg. D.O. per l. and carbonate hardness of 5° (German) and no aggressive CO_2. Corrosion may also be prevented by altering chem. compn. of water, for example, by removing D.O. Various methods for control of corrosion in hot-water plants described. These include filtration to remove suspended and colloidal matter, and filtration through materials which will remove carbonic acid, or through materials which will remove D.O. Types of app. for regulating addn. of chem. reagents used for removing D.O. or for encouraging development of protective layer described.—*W.P.R.*

Porcelain Enamel as a Protective Coating for Hot-Water Tanks. D. R. GOETCHIUS. J. &. Bul. Am. Ceram. Soc. **25:** 165 ('42). For protection of hot-water tanks, compn., temp. and pressure of water must be taken into consideration. Water treated for public supplies in U.S. generally has pH value within range 5–9 and content of dissolved solids varies from very low value to more than 400 ppm. Tests made to compare suitability of zinc and porcelain enamel as protective coatings using ten 15-gal. tanks; five of these enameled with one ground coat and one dipped-cover coat of blue, non-acid-resisting enamel of special compn. and milled with black oxide; other five galvanized by hot-dip method. One tank in each set subjected to action of steam at pressure of 10 psi.; complete disintegration of surface of enameled tank occurred after 32 days of testing; after 217 days, galvanized tank unaffected except for slight darkening of surface. Four remaining tanks in each set treated respectively with acid water (pH 5), alk. water (pH 9), water contg. 500 ppm. sodium chloride and 500 ppm. sodium sulfate, and normal tap water. Water changed weekly and aerated twice daily during week days. Results showed that enameled surfaces possessed greater degree of resistance over wider range of conditions than galvanized surfaces. With enameled surfaces increase in temp. increases severity of corrosion. Only slight deposition of salts occurred on enameled surfaces, but in galvanized tanks, large deposits of salts formed with all except acid waters. Loss in weight of enameled surfaces in contact with water detd. using non-acid-resisting and acid-resisting enamels. Non-acid-resisting enamels less soluble. Enamels milled with barium carbonate less soluble than those milled with sodium nitrite or borax. Resistance of enamels can also be partially predicted from soly. of enamel frit;

test recommended is to leach quant. of frit with water at high temp. and to det. content of alkali and boric oxide in water. Concluded that use of acid-resisting enamel not necessary for protection of hot-water tanks; good enamel should have frit resistant to extraction with hot water and satisfactory under pressure tests. Heavy coating of enamel should last much longer than galvanized surface.—*W.P.R.*

Corrosion Prevention on the Water Side of Refinery Equipment. W. H. ATTWILL & V. L. NEALY. Refiner Natural Gasoline Mfr. **20:** 242 ('41). *A. Chemical Treatment of the Water.* Describes tests carried out at oil refinery at Port Arthur, Tex., to det. best method of treating water to prevent corrosion in cooling towers. Addn. of caustic soda or of sodium silicate did not reduce corrosion. Addn. of sodium dichromate then tried and great reduction in corrosion of copper-base condenser tubes and of steel and c-i. supply lines immediately apparent. Chromate treatment now in use in 5 cooling tower systems at refinery. Concn. of 500 ppm. sodium dichromate maintd. in circulating water, together with 5–10 ppm. total phosphate maintd. by adding sodium hexametaphosphate. Metaphosphate tends to prevent mineral deposits and to improve corrosion-resistant properties of chromate film. Expts. now in progress on use of metaphosphate to inhibit corrosion, but the results so far obtained show protection less than with chromate treatment. *B. Use of De-Aerator.* Mech. de-aerator installed to reduce corrosion in cooling tower at oil refinery. Cooling water soft and has pH of 8.0–8.5. In de-aerator water flows downwards through tray section, and oxygen released drawn out through vacuum jet. Content of D.O. in water reduced from 6–7 to 0.12 ppm. Corrosion of condenser tubes and water supply lines greatly reduced since de-aerator installed. *C. Cathodic Protection.* Cathodic protection recently applied to prevention of corrosion in condensers. In one at oil refinery using water from Neches River, Tex., tube failures used to occur every 3–6 mo. Since installation of cathodic protection, condenser operation for 15 mo. without failure. Installation described.—*W.P.R.*

The Attack of Carbon Dioxide on Blades of Turbines. G. HEINZ. Wärme (Ger.) **63:** 261 ('40). CO_2 will corrode parts of machines working at high temps. when it exceeds certain threshold value. Value ascertained to be approx. 10 mg. per l. at 50 atm. and 475°. Since river water has carbonate hardness of at least 40 during most of year, and since Na_2CO_3 decomposes at steam pressures above 40 atm., river water softened by base-exchange should be avoided in h-p. boilers. Where such water must be used, condensate should be freed of carbonates or of salts in general.—*C.A.*

Corrosion of Boiler-Water Pumps. M. WERNER. Korrosion u. Metall. (Ger.) **18:** 164 ('42). Shown by expt. that thermoelec. local currents may be caused by temp. differences such as those existing in condensers. Not likely, however, that they play large part in corrosion observed. Also shown that pump corrosion cannot be explained solely by weakly acid reaction of water, high temp. or by any sulfite content. Considerable amts. of Cu shown in corrosion products of h-p. boiler pump and assumed that corrosion caused by pptn. of Cu and formation of local elements. Cu can go into soln. only when O_2 present. Complex Cu ions have no corrosive effect. Sulfide can be formed from sulfite only in acid medium. However, in presence of Fe-Cu couple, sulfide may also be formed in alk. medium and at room temp. To prevent corrosion, recommended to use Cu-free material for constr. of pumps (such as Cr-contg. castings), to maint. pH of water above 7.5 and to elim. O_2. If latter done by means of hyposulfite instead of sulfite, Cu ions rendered harmless.—*C.A.*

Low-Cost Treatment Rescues Process Cooling-Water System. R. Y. CASE & S. F. ALLING. Power **85:** 474 ('41). Cooling water used in rubber-processing equip. aerated at 57°F. and sand-filtered to remove most of Fe contained in water (without this treatment, water formed excessive Fe deposits in piping system). Sand filters periodically backwashed with air and water. By this method, sol. Fe reduced from 23.5 to 0.40–0.50 ppm.—*C.A.*

Keep Your Condenser Tubes in Service. F. G. SMITH. So. Pwr. & Indus. **60:** 136 ('42). Factors causing condenser-tube failures are: excessive local turbulence, finely divided air bubbles and solids in cooling water. Local turbulence greater at inlet ends when common ferrules used instead of rolled and flared tubes. Excessive aeration of cooling water should be avoided and air-elimn. means used if necessary. If more or less

stagnant water used, basin should be dredged clean at least once a year or decompg. org. matter may be carried into condenser. Shell formation in intake, slime, etc., can be reduced by suitable chlorination of water. Repairs with flared sleeves at inlet end should be made in such way as to avoid shoulders causing turbulence. When tubes have failed only at inlet end and only slightly corroded elsewhere, can be stretched and re-used. In retubing condenser, sound tubes can be re-used in that part of condenser showing least corrosion.—*C.A.*

Effect of Water Chlorination on Corrosion of Brass Condensor Tubes. F. B. SLOMYANSKAYA. Korroziya i Borba s Nei (U.S.S.R.) **6:** 1: 14 ('40). Purpose of study detn. of losses due to corrosion of brass pipes as function of Cl concn. in tap water. Process electrochem. and in first stage represents transfer of metallic Cu and Zn into ionic state. Used and new imported tubes and new domestic tubes investigated; they contained, resp., Cu, 79.91, 67.88, 70.40; Zn, 29.009, 31.88, 29.87; Pb, trace, trace,—; Fe, 0.04, 0.09, 0.03; Sb, 0.001, 0.001,—; Bi, trace, trace,—; Sn, 0.04, 0.20, 0.23%. Tap water chlorinated (0.1 mg./l.); in addn. some Cl added in lab. and 4 different media produced: (a) Cl 0–0.1 mg./l.; (b) 0.25 mg./l.; (c) 0.5 mg./l. and (d) 1 mg./l. Temp. was 18–21°. Deg. of corrosion expressed in g. per sq.m. per hr. loss in wt. of sample. Rate of corrosion also detd. by speed of formation of protective film, possibly $CuCl_2 \cdot 3Cu(OH)_2 \cdot H_2O$. Used tubes corrode much less than new ones; of new tubes, domestic corrode more than imported. Lower resistance of domestic tubes attributed to insufficient thermal treatment.—*C.A.*

Promotion of the Corrosion of Iron in Alkaline Solutions by Zinc and Aluminum. GUSTAV NILSSON. Science **152** (Aug. 14, '43). Zn-preventive action on iron corrosion well known as galvanized iron. Al tried for same purpose. In special cases, however, small amts. of Zn and Al have opposite action, i.e., iron passivated in strong HNO_3 activated by contact with Zn, after which readily corroded. In certain alk. solns., similar reactions may occur. Earlier studies often showed well-defined difference between passive and active iron in same alk. soln. With former, attack slight, if any; metal remains bright and soln. uncolored. Active iron corrodes rapidly, surface darkens and sometimes darkens soln. With special reagents coloration intense and observable immediately after activation. Thus reagent becomes indicator. In other cases, first corrosion signs evident only after days or weeks. Change from passive to active state affected by cathodic action causing reduction of protecting oxide layer on iron. To produce this action contact with only small amts. of Zn or Al necessary. When less noble metal later removed or dissolved, iron remains in active state. Supporting expts. described.—*Ralph E. Noble.*

The Influence of Stress on the Corrosion Pitting of Steel in Distilled Water. D. J. MCADAM, JR. & G. W. GEIL. Trans. Am. Soc. Metals **30:** 1159 (Dec. '42). Specimens previously corroded in distd. water, with or without stress, examd. to det. stress effect during corrosion on form, size and distr. of corrosion pits. Latter formed in distd. water smaller and shallower than those in well water. Cyclic stress tends to increase pit size and relative depth. Steady stress, sufficiently high, accelerates corrosion pitting in distd. water, but not appreciably in well water. At sufficiently high stress and cycle frequency, crevices and fissures project from initially rounded pits. Form, size and distr. of corrosion pits correlated with lowering fatigue limit, being much slower in distd. than in well water, owing to difference in size and relative depth of pits. Diagrams representing const. total and net damage caused by corrosion in distd. water differ greatly from those for well water owing to steady stress influence on corrosion in former. Brief discussion given of stress corrosion process and of practical importance of fact steady stress under some corrosion conditions may accelerate steel pitting.—*Ralph E. Noble.*

Breakdown of Paraffin Wax by Bacteria: A Source of Error in Corrosion Tests. T. HOWARD ROGERS. Nature (Br.) **152:** 105 (July 24, '43). In work by Br. Non-Ferrous Metals Research Assn. on metals corrosion by domestic waters, glassware for water sampling and corrosion tests coated with paraffin wax to prevent alkali silicate pick-up. Tests with waxed containers, or with water conveyed in them, gave inconsistent and non-reproducible results. Occasionally noted that wax coatings of some carboys attacked and gradually disintegrated, suggesting bact. activity. Water from affected carboy inoculated into nutrient soln. contg. paraffin wax

as only source of C, and incubated at 30°C. Wax-attacking bacteria developed after few days. Species doubtful but suggestive of *Micrococcus paraffinae*, aerobic, of soil origin and found in surface waters. Studied effect of this bact. action on apparent free CO_2 of water stored in wax containers. Exptl. set-up described. Free CO_2 detd. by titration with N/20 Na_2CO_3 using phenolphthalein indicator. Any org. acids formed by bacteria would be estd. as free CO_2. Found that water in closed wax containers contamd. with wax-attacking bacteria increased its free CO_2 on storage 20 times in 40 days, compared with no change in unwaxed bottle controls. Bact. activity stopped by heat sterilization or disinfectants. Effect of wax bacteria upon corrosion of domestic water in metal pipes closed at both ends with wax indicated by table:

Condition of Water	*Corrosion Rate*
Untreated water, wax bacteria free	0.9
Water inoculated with wax bacteria	4.1
Sterilized water	0.7
Sterilized water re-inoculated with wax bacteria	4.0

Other biol. factors affect apparent free CO_2 in water, however. Seldom safe to assume any stored sample of natural water representative of initial condition.—*Ralph E. Noble.*

Cathode Protection for Pipe. ROBERT R. ASHLINE. Western Constr. News **18:** 309 (July '43). Life extended and steel of oil, gas and water pipelines conserved by *cathodic protection*. Line leak wasteful, destructive, dangerous and expensive. Metal corrosion caused by direct current leaving pipe surface carrying with it minute quants. of metal into surrounding medium. Tendency often present when pipe passes through low resistance, corrosive soils. Current stoppage or reversal prevents. Introducing direct current into earth by multiple anode system of junk steel pipe causes current flow to and collection upon pipeline surface, thus overcoming tendency of current to leave pipe, stopping most of corrosion. Current flows back through pipe line and bond wire to d-c. source. Salt poured into trench contg. horizontal junk steel pipe acting as anode, lowering contact potential of steel with surrounding earth. Various type rectifiers deliver d-c. power. Where power unavailable, wind or motor-driven generators used. Possibly certain type batteries usable where not much current needed. Installation size and current required depend upon: (1) length and size of pipe to be protected; (2) condition of pipe coating; (3) soil resistance in area; and (4) position and size of anode available. Rectifier should be several hundred ft. from pipeline. Installation cost not excessive. Monthly power cost low as most rectifier effs. about 65%. That of 3-phase rectifier even higher. Typical installation by Los Angeles Bur. of W.W. and Supply described.—*Ralph E. Noble.*

Protection of Large Iron Pipes Against Corrosion. RESSMANN. Gas-u. Wasser. (Ger.) **83:** 393 ('40). Fused-clay cement applied to inside walls of water tanks and pipes of Hamburg water supply proved successful in preventing corrosion. Cement mixed with equal quant. of fine sand and little water to form paste which is applied with brush. Method of applying coating and results of its use in iron and steel pipes carrying aggressive ground water described.—*W.P.R.*

Identification of Rust on Iron and Steel. RALPH O. CLARK. Ind. Eng. Chem.—Anal. Ed. **15:** 464 (July '43). Gelatin paper, moistened with water and appressed, for 15-30 sec., to surface examd., will remove sufficient iron rust for testing, without affecting underlying metal. Paper prepd. by fixing unexposed photo paper in sodium thiosulfate soln., treating in hypo-eliminator soln. (Kodak formula HE-1) and drying. For development, test paper immersed in 10% hydrochloric acid contg. 0.05% potassium ferrocyanide soln. for 10–15 sec. Sharp rust pattern forms. Sulfide films from copper or lead do not form patterns because of fine structure and close adherence of coating.—*A. A. Hirsch.*

Protection From Rust by Phosphate Coatings. ANON. Pumpen. u. Brunnenbau (Ger.) 685 ('41); Wass. u. Abwass. (Ger.) **40:** 37 ('42). Various methods can be used to protect surfaces of iron and steel. Metallic coatings of tin, copper, nickel, chromium, etc., formed by galvanizing process often not suitable for present conditions. Conversion of surface of iron into insoluble iron phosphate by immersion of iron in soln. of phosphates of certain metals, without use of elec. current, forms firmly adherent protective layer. Surface to be treated must be free from grease and oxides, otherwise phosphate layer adheres badly. Grease removed by treatment with hot lye and rust by pickling or sand-blasting.

Phosphate coating forms suitable surface for painting. Treatment takes only 3–5 min.—*W.P.R.*

Position of Our Knowledge Regarding Corrosion and Protection Against Corrosion of Iron and Steel. F. EISENSTECKEN. Ber. Werkstoffausschusses Ver. Dtsche. Eisenhüttenleute (Ger.) **464**; Stahl u. Eisen (Ger.) **59**: 537 ('39); Gas-u. Wasser. (Ger.) **83**: 394 ('40). Surveys literature during last few yr. on corrosion and prevention of corrosion of iron and steel. Electro-chem. theory of corrosion discussed. Elements other than iron in normal amts. in steel probably do not influence corrosion but presence of more than 0.12% of sulfur accelerates corrosion in acid solns. Addn. of copper to steel retards corrosion in air and in dil. acid solns. but not in neutral or alk. solns. or in sea water. Influence of cold rolling of steel on corrosion still disputed; other factors probably or greater importance. Type of welding greatly influences corrosion of seams. Intercryst. corrosion of steel can generally be avoided by reducing amt. of carbon or by addn. of other elements to form alloys. Corrosive effect of soil depends on power of soil to hold water, its permeability to oxygen and pH value and chem. compn. of soil soln. Expts. made in Holland show that anaerobic bacteria in soil contg. sulfates produce hydrogen sulfide; acid sulfates may then be formed in presence of oxygen. Pipes can be protected by surrounding them with clay or loam or with soil to which lime added, or by bituminous coatings. Interiors of pipes can be protected by bituminous coatings or by treatment of water passing through them. Various methods of preventing corrosion due to elec. currents described. Corrosion in hot-water systems controlled by removal of D.O. Corrosion in steam boilers reduced by reducing content of D.O. in water to less than 0.5 mg./l. and increasing pH value to above 9.6. When not in use, boilers filled with softened water contg. no D.O. or dried with activated carbon, silica gel, etc., to prevent corrosion. Descriptions of metallic and non-metallic coatings for pipes given. Resistance to corrosion of a material under working conditions cannot be detd. by lab. expts.—*W.P.R.*

Corrosion by Carbonic Acid and Non-Volatile Acids in Cold and Warm Water as Observed in Norway. L. HAASE. Korrosion u. Metal. (Ger.) **18**: 145 ('42); Chem. Zbl. (Ger.) **2**: 830 ('42). Surface waters in Norway so far studied from point of view of their corrosive properties, practically free from compds. causing hardness and contain very little CO_2. Their content of non-volatile org. acids produces comparatively high acid value (amt. of acid divided by pH value). Observation of action of these acids (humic acids, lignin substances) on most common materials of constr., particularly iron, showed difference between surface waters contg. practically no CO_2 and ground waters contg. CO_2 where these had originally same pH value. Kind of acid and not no. of hydrogen ions present, therefore, important factor. Since products of corrosion soluble, even cold water causes very considerable corrosion and particularly troublesome in pressure pipes of power houses. Water contg. aluminum oxide and silica, as well as suspended matter, may cause even more severe erosion of metal, but this can be mitigated by choice of suitable constructional materials, such as chromium steel contg. no nickel. Protective layers formed in galvanized pipes. If water to be used for supply, must be de-acidified; this cannot be done with calcium oxide but use of filtering materials contg. magnesium appears promising.—*W.P.R.*

How Much Does a Leaking Faucet Waste?

THE water conservation program handbook contains many references to the waste of water through leaking fixtures. In the hurly-burly of getting the material ready for water works men to use, it was not discovered until later that the source material for the several representations of leaking faucets and the gallons total lost for each size leak were not in accord with one another. Some of our correspondents have "lifted a mathematical eyebrow" at the figures we used. Publicity material which is coming in from over the country adds to the variety of information on the subject.

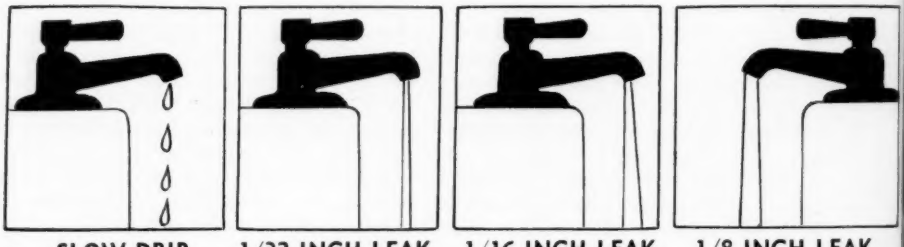
Of course, when we stop to consider the matter carefully, our visions of precision go glimmering. When we speak of a $\frac{1}{8}$ *in. leak* from a faucet we might mean the amount of water that would flow under pressure through an orifice in the service pipe back of the faucet. We might refer to the amount that would, after discharge from the faucet, flow evenly through a vessel that had an exact $\frac{1}{8}$ in. orifice in the bottom. Or, we might by some abstruse mathematics attempt to calculate the area open around the edge of a faucet washer that did not rest firmly on the washer ring.

Naturally, we all know that if the calculation of waste is based upon the flow through a faucet or orifice of any sort under pressure, the flow will increase with the pressure. This means that for downright accuracy and comparability of figures, the estimate of quantity of water lost from a leaking faucet should be computed by measuring the flow through an orifice after the water has fallen freely from the faucet into a measuring chamber.

In the meantime, the record can show this: The figures used for $\frac{1}{32}$, $\frac{1}{16}$ and $\frac{1}{8}$ in. flow in the illustration *Uncle Sam Wants Water Waste Stopped* are based upon Freeman's table * with flow at 40 lb. pressure. A factor of 0.6 was applied to the basic data to adjust for the high friction loss under leakage conditions. As would be expected, the figures thus derived *approximate* a four times increase for each doubling of the diameter and are rounded off so as not to simulate accuracy that does not exist.

Someday we hope that an interested member of the Association who has a meter shop at his command, will develop a series of figures (based upon actual leaking faucets) for the range of pressures commonly met in water works practice, which can be used in future references to water waste. It will be worth while. *Harry E. Jordan*

* Trans. A.S.C.E., Vol. 21.



SLOW DRIP
15 gallons per day
105 gallons per week
5,475 gallons per year

1/32 INCH LEAK
165 gallons per day
1,155 gallons per week
60,225 gallons per year

1/16 INCH LEAK
650 gallons per day
4,550 gallons per week
237,250 gallons per year

1/8 INCH LEAK
2,520 gallons per day
17,640 gallons per week
919,800 gallons per year

Any Way It's Figured

It's Still a Leaking Faucet

What Leaks May Cost

	Size of Leak	Gallons per 24 Hours	Gallons per Month	Cost per Month
1/4"	◯	12,300	375,150	$60.05
1/8"	○	3,200	97,600	19.65
1/10"	○	860	26,230	6.35
1/32"	•	215	6,550	1.97

Above estimates are based on Indianapolis pressure without allowance for friction loss

Do you know that

A dripping faucet

Consumes—
15 gallons per day
450 gallons per month, or
60 cu. ft. per month.

Consumes—
2,906 gallons per day
114,300 gals. per month, or
15,317 cu. ft. per month.

1/32 inch opening

Consumes—
264 gallons per day
7,920 gallons per month, or
1,016 cubic ft. per month

Consumes—
15,120 gallons per day
456,800 gals. per month, or
60,907 cu. ft. per month.

1/10 inch opening

Consumes—
943 gallons per day
28,300 gallons per month, or
3,773 cubic ft. per month.

Consumes—
60,900 gallons per day
1,827,000 gals. per month, or
243,600 cu. ft. per month.

Figures above on basis of 40 pounds average pressure.

1/8 inch opening

1/4 inch opening

1/2 inch opening

STOP THAT DRIP!

Dripping faucet consumes 15 gal. per day— 450 gal. per mo

1-32" opening consumes 264 gal. per day— 7,920 gal. per mo.

1-16" opening consumes 943 gal. per day— 28,300 gal. per mo

1/8" opening consumes 3,906 gal. per day— 114,300 gal. per mo

1/4" opening consumes 15,120 gal. per day— 456,800 gal. per mo

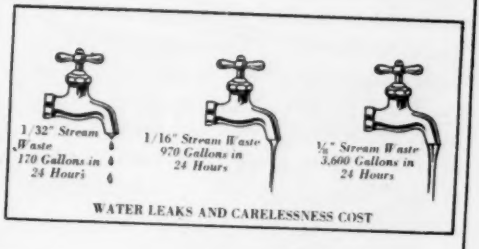
1/2" opening consumes 60,900 gal. per day— 1,827,000 gal. per mo.

WATER COSTS MONEY DO NOT WASTE IT

Leak Through Opening of	Gallons per Month Wasted	At a Cost to You of
1/4"	400,000	$83.11
3/16"	225,000	52.31
1/8"	100,000	26.95
1/16"	25,000	6.95
1/32"	6,300	1.73

Pressure 60 lbs.

CITY OF SAN DIEGO WATER DEPT



WATER LEAKS AND CARELESSNESS COST

Sioux Falls Water Works

OF THE

CITY OF SIOUX FALLS
SOUTH DAKOTA

CAUTION

THIS IS THE WAY LEAKS RUN INTO MONEY

1-64 inch leak, wastes gals. per day	48
1-32 inch leak, wastes gals. per day	192
1-16 inch leak, wastes gals. per day	816
1/8 inch leak, wastes gals. per day	3,288
1/4 inch leak, wastes gals. per day	12,336
1/2 inch leak, wastes gals. per day	49,368

Above figures based on 40 pounds average pressure.

How Water Is Wasted

Few people are aware of the huge quantity of water that will flow under pressure, through very small openings. The accompanying figures give this information.

Based on Only 40 Lbs. Pressure

This size stream from a 1/8 inch opening will flow 100 cubic feet per hour or 1,250 gallons per hour.
In one month 972,000 gallons
Cost of waste @ 25c per 1000 gal. $243.00

This size stream from a 3/16 inch opening will flow 50 cubic feet per hour, or 375 gallons per hour.
In one month 270,000 gallons
Cost of waste @ 25c per 1000 gal. $67.50

This size stream from a 1/4 inch opening will flow 25 cubic feet per hour, or 187 gallons per hour.
In one month 168,000 gallons
Cost of waste @ 25c per 1000 gal. $37.00

This size stream from a 1/16 inch opening will flow 4 cubic feet per hour or 30 gallons per hour.
In one month 21,600 gallons
Cost of waste @ 25c per 1000 gal. $5.40

This size stream from a 1/32 inch opening will flow 1 cubic foot per hour or 7½ gallons per hour.
In one month 5,400 gallons
Cost of waste @ 25c per 1000 gal. $1.35

DISCHARGE IN GALLONS PER HOUR

1/2 — 1,200 Gallons
1/4 — 375 Gallons
1/8 — 100 Gallons
1/16 — 30 Gallons
1/32 — 7½ Gallons

40 Lbs. Pressure

COMPLIMENTS OF SPARTANBURG WATER WORKS

Posters for Water Conservation

If the policy of your Utility or Department is such as to approve the customer's repair of leaking faucets, you can add "Fix the Faucet Yourself," to the use water usefully—don't waste it campaign.

You should remember that Civilian Defense agencies have in recent months operated training courses in many cities to instruct civilians how to do minor repair jobs in case a plumber, an electrician, or other skilled help, is not procurable.

Life Magazine, for July 26, 1943, contained a series of illustrations of "How to Fix It." One page shows a sequence on putting a washer in a water faucet. With permission of *Life* the photographs were set up into the form of a three color poster illustrated on the next page. It is included in *Water Conservation* (*see* p. 379).

The inclusion of this copy is not intended to promote the indiscriminate extension of amateur activity into the craft field. It is based upon the simple assumption that the best evidence of customer consciousness of the need for waste control is some positive step that the customer himself takes. Fixing the dripping faucets would certainly be such a step. If customers do these small jobs themselves, then your campaign must be catching on.

Prices covering this poster and the other three in the *Water Conservation* book are:

1,000 (any one poster design)	$20.00
1,000 (set of four, 250 each)	15.00

Place your order *today* with the American Water Works Association, 500 Fifth Ave., (18) N.Y.

WATER CONSERVATION BOOK NOW $1.00

© A.W.W.A.

Willing Water says—

Opportunity is knocking! All water works men who have not yet ordered a copy of the book *Water Conservation,* heretofore sold for $2.00 a copy, will want to order one or more copies. Those who already have copies will want to order more. The book contains a host of practical ideas for use in planning water conservation programs. Everything from leak surveys to radio program scripts is covered. *Willing Water,* cheerful worker for water works systems makes his initial appearance in the book. There are newspaper advertisements, mailing pieces and posters included in the Book, which can be ordered through the American Water Works Association. Write today for your copy of *Water Conservation!* It is now only $1.00.

IF YOU CAN'T GET A PLUMBER

—MAYBE YOU CAN FIX THE LEAK!

Turn off water before starting any plumbing repairs. If the sink has no cut-off under basin, turn water off in basement.

To take a faucet apart, clamp a monkey wrench around the cap nut (see above) and then loosen by turning as indicated.

This is the spindle. Unscrew or lift it out of faucet. Washer is at spindle's end. When washer is worn out, faucet leaks.

Small screw keeps washer in place. Remove the screw and faulty washer. If washer sticks, pry away with small knife.

New washer must be the same size and shape as old one. Screw the new washer onto spindle and reassemble faucet.

STOP WATER WASTE

Photos by courtesy Life Magazine
copyright Time Inc. 1943

War Production Board

CMP Regulations 5A—Maintenance, Repair And Operating Supplies

Editorial Note: War Production Board Order CMP Regulation 5A was amended on February 2, 1944. This order relates to maintenance, repair and operating supplies for governmental agencies. It does not cover water supply or sewers, but since many water works superintendents have to do with other municipal functions, there follow the schedules of ratings which can be applied to purchases by governmental agencies.

Schedule I—Preference Rating AA-1

Hospitals.
Refuse and garbage collection and disposal.
Communicable disease control.
Alcan, Richardson, Steese, Glenn, Pan-American and Trans-Isthmian highways.
Public transportation facilities.
Docks, wharves and terminals.
Police and law enforcement agencies.
Anti-espionage and anti-sabotage activities—Federal agencies only.
Fire protection.
Beacons, markers, and radio devices employed as aids to navigation.
U.S. Post Office Department.

Schedule II—Preference Rating AA-2

Public streets, highways and roads.
Airports and flight strips.
Dams, levees and revetments.
Drainage and irrigation.
Canals-waterways.
Flood control facilities.
Farm labor camps operated as a part of the War Food Administration's migratory labor program.
Mineral resources: exploration for (governmental agencies only).
Storm sewers.
Street lighting, by governmental agencies which are not engaged in the business of furnishing electric power for use by the public, except in cases where equipment is maintained by a utility company.
Supplying gas, water, electric power, or central steam heating, by a governmental agency, when such service is for its own use exclusively.
Public dispensaries, clinics and health stations, governmentally-owned or operated not for profit.
Penal institutions and prisons including prison industries.
Mine safety.
Printing and publishing.
United States Mint.
United States Bureau of Printing and Engraving.
Processing, warehousing, distribution, preparation, serving and inspection of food by Governmental agencies only.
Over-all administration including staff services, such as fiscal procurement, personnel, etc., by Governmental agencies only.
Repairs made necessary by reason of any breakdown of plumbing, heating, electrical wiring or equipment, or elevator service in any building or to provide against imminent breakdown of any such facilities by Governmental agencies only.
Publicly-owned buildings which are used for Governmental activities.
Educational institutions.